Studies on the fishes of the family Sciaenidae of India

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CERTIFICATE

This is to certify that this thesis entitled "Studies on the fishes of the family Sciaenidae of India" submitted by Mr. R.S. Lal Mohan, M.Sc., for the Degree of Doctor of Philosophy in Zoology to the Madurai University, is based on the results of studies carried out by him. This thesis, or any part thereof has not been submitted elsewhere for any other Degree or Diploma.

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PREFACE

The fishes of the family Sciaenidae constitute one of the commercially important fishes of India. Though attempts have been made to study this group earlier, no comprehensive account is available. In the present study 37 species of sciaenid fishes are described and the biology of Pennahia macrophthalmus is investigated in detail.

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CONTENTS

GENERAL INTRODUCTION

India, with its 5680 km of coastline and the continental shelf of about 5.8 million sq.km., has vast marine fishery resources (George, 1974). The average annual marine fish landings in India during the years 1962 - 1974 was 950427 tonnes (Silas et al, 1976). The pelagic fishery resources consisting of sardines and mackerel constitute about 60% of ~~tk~~ our fishery resources. The annual marine fish production in India for 1974 has been estimated to be 1.218 million tonnes. Prawns which form one of the important constituents of the demersal fishery play a unique role in the national economy as they earn foreign exchange of about 600 million rupees. The fishing industry employs nearly one million fishermen who are spread over in about 2000 villages. The fishing crafts of India, though largely conventional, numbers about 100,000 of which about 10% are mechanised.

Sciaenids are one of the commercially important groups of marine fishes. Annually about 40,000 tonnes of sciaenids valued about 40 millions of Rupees are landed in India forming nearly 4% of the annual marine fish landings. The total sciaenid fish landings of Maharashtra were 11097 tonnes. In Tamilnadu 6230 tonnes of sciaenids worth about 6 million Rupees were landed in 1974. Sciaenid fishes form approximately 6% of the marine fish landings of the State.

Though India has made great strides in various fields of fisheries since independence, the growth in population demands more and more of food. As the sea is the source of ~~ajmax~~ cheap protein food, it is expected that the deficiency in protein can be reduced by increasing fish production. But the self-generating capacity of the fish is limited and this capacity cannot stand the pressure of sophisticated technology beyond certain limits. If the reduction in stock due to mortality (fishing and natural) of the fishes is replenished by recruitment and growth, the stock will be maintained at equilibrium. But if the total mortality is more than the self-generating capacity of the fish, eventual depletion of the stock may ensue. It is where the management of the stock plays an important role. It is needless to say that without the proper understanding of the biology of the fish, management of the stock is not possible.

It is with this background, the studies on the fishery and biology of Pennahia macrophthalmus were taken up. The taxonomy of the sciaenid fishes was studied as the identity of many species and the descriptions of some genera were not clear. Due to many converging external characters, different species were considered identical whereas in some cases same species recorded from different areas were treated as distinct species. 37 species belonging to 16 genera are described here.

Knowledge of food and feeding habits is important as they influence the growth of fish. If the availability of food is limited, the average growth of the population will be affected. Similarly the availability of food influences shoaling behaviour, migration etc. Besides, food studies provide valuable information on food and growth and energy flow in eco-system. Much work has been done on the food and feeding habits of Indian fishes and a good deal of information has been gathered on the food of a number of commercially important fishes (Qasim,1972). Some of the important works are those of Hornell and Nayudu (1924), Devanesan (1932), Nair (1950, 1952), Sekharan (1971) and others. In the present investigation quantitative and qualitative analysis of the food of P. macrophthalmus along with the seasonal variation of food, food in relation to size groups, condition of feed, food selection and food of other sciaenids have been studied.

The length-weight relationship has been studied as it is useful to find out one of the parameters (length or weight) if the other is known. The suitability of the environment and the interaction between physico-chemical factors and the fish also can be inferred. Similarly the condition factor (K_n) has been studied to trace the 'condition' of the fish during various months as it provides evidence for the breeding season of the fish.

Growth is a process which may be considered as the product of manifestation of assimilation of food not diverted to such purposes as respiration, muscular activity and maturation of gonads. Age and growth have been studied as the fluctuations in abundance of the resources are often accompanied by changes in size of fish. Petersen (1894) observed that length frequency distribution of samples from fish catches showed several modes and he deduced that these modes represented year classes. Hoffbauer (1898) showed that growth of scale and fish are closely related. Later Hjort (1914) and Lea (1929) followed a dominant age group in samples from the herring fishery and showed that number of annuli increased each year and growth zones could be followed in successive years. Some of the important works on age and growth are those of Van Oosten (1928), Graham (1929), Hile (1936) and others. Otoliths, vertebrae, opercular bones and spines of fins were also used by various authors to determine age in fishes (Graham, 1929; Palmen, 1956; Pantulu, 1961).

As the age of fish can be determined, it is possible to estimate growth rates and mortality of the fish population. Age and growth correlation can be used to convert the measurement into estimates of age. Thus catch and stock can be expressed in terms of age. This information can be carried right through the sampling system. Lengths for an age class based on catches can be compared from year to year growth rates. Determination of growth rates based on length of age group is often beset with difficulties in the older year classes.

Beverton and Holt (1957) used description of growth and mortality with reference to age as an essential part of their equations in an analytic manner. There are many equations describing the decrease of specific growth with age. Von Bertalanffy's equation describes the rate of change of length with time. Another form of equation is expressed in Ford-Walford plot. Gomperts's equation also explains the rate of change of length with time.

Age of *P. macrophthalmus* was determined by length frequency and probability plot methods. The hard parts were not found to be useful for age determination. Growth curves for length and weight were fitted by von Bertalanffy's and Gompertz's equations. Both these equations gave good fit to the growth and weight data.

The knowledge of reproductive biology of a species is important as it is intimately related to the understanding of the dynamics of the population, abundance and spawning behaviour. Estimates of abundance of eggs and larvae have been used for predicting abundance of adult fish (Hjort, 1914). As larval mortality is the principal cause of fluctuation in abundance, this hypothesis has generated interest in scientists to study the fecundity and larvalabundance of fishes. Fecundity of the species may vary from year to year affecting the strength of the brood (Nikolsky, 1953). Information on spawning and early development is useful in recruitment studies. Fishes usually spawn in restricted areas, thereby forming heavy concentration in the spawning area. This behaviour is of great importance for exploitation and also for the conservation purposes.

As a part of the investigation of the biology of the sciaenid fish Pennahia macrophthalmus maturation of gonads, spawning season, spawning frequency, gonadosomatic index, weight and length at first maturity, relation between ova doameter and total length, fecundity and sex ratio were studied.

Racial investigations are taken up to identify the stock. The identificatión of sub-population is considered to be important because management of maximum sustainable yield requires that each stock or race should be managed separately. Within the limits of distribution of a species a number of geographical races or sub-populations may exist. When an entire fishery depends entirely on any one stock, it will be affected by the quantities caught in any locality. But if the stocks are local each must be treated as a separate unit and fishing in one locality may not affect the stock elsewhere. However, an ideal unit stock has a single spawning ground to which adults return for breeding. Evidences to establish distinct sub-population can be gathered by studying age, length at first maturity, distribution, tagging, migratory behaviour, morphometric and meristic characters, structure of otoliths, aminoacids of muscles, antigenic properties, electrophoresis of blood etc.

The morphometric characters of P. macrophthalmus from different localities were studied to determine whether they belong to the same stock or different stocks.

There are very few studies on parasites of sciaenid fishes of India. In P. macrophthalmus the infestation of the gonads by the nematode parasite Philometra rajani was studied. A new external nematode parasite, Philometra nairii has also been described from P. macrophthalmus.

The fishery and distribution of sciaenid fishes along the Indian coasts were studied to assess the importance of sciaenid fishes in the various maritime states. The species composition of sciaenids was discussed with special reference to commercially important species.

As a part of demersal fish resources, the importance of sciaenid fishes is bound to go up in India due to increase trawling activities along the coasts. The present work which deals with the taxonomy of fishes of the family Sciaenidae and the biology of the sciaenid fish Pennahia macrophthalmus is carried out to give a comprehensive account of this important fish resource.

PART : I

I. TAXONOMY

TAXONOMY

Introduction:

Sciaenid fishes are one of the earliest known groups of fishes. Linnaeus (1758) described the sciaenid fishes *Sciaena cirrhosa* and *S. umbra* of Mediterranean and Atlantic. Since then this group has been studied by many workers. There are about 140 species of sciaenids in the world.

In India, 37 species of sciaenids are known at present, Bloch (1793), Lacepede (1802), Russell (1803), Hamilton (1822), Cuvier (1830), Gunther (1860), Day (1878), Pillai (1929), Fowler (1933), Weber and de Beaufort (1936), Jacob (1948) Munro (1955), Chu *et al.*, (1963), Dutt and Thankam (1969) Talwar (1971 a.b.c; 1971) and Mohan (1972 and 1973) are some of the workers who have contributed to our knowledge of Indian sciaenids.

Cuvier (1830) recorded 23 species of sciaenids from India under four genera; Gunther (1860) described 23 species in five genera and, Day (1878) 27 species under four genera; Fowler (1933) studied 31 species placing them in six genera; Weber and de Beaufort (1936) also described 22 species under six genera. These authors based their classification on external morphological characters like lateral line pores on snout and lower jaw, fin ray counts, dentition and length of second anal spine. Due to similar ecological habitats, different external morphological characters tend to converge resulting in apparent external similarities. These apparent external similarities led to the inclusion of widely separated species in the same genus (ex. Kathala axillaris in the genus Johnius Bloch) by the earlier authors.

Though Cuvier (1930) and Day (1878) made references about the gas bladders while describing the sciaenid fishes, they did not give any taxonomic importance to these characters. Trewavas (1962) stressed the importance of gas bladders while studying the sciaenid fishes of South Africa. Later Chu, et al (op.cit.) classified the sciaenid fishes of China based on the gas bladder and otoliths. Dutt and Thankam (op.cit.) partially adopted the structure of the gas bladder in classifying sciaenids and recorded 13 species of sciaenid fishes from Waltair coast under 5 genera. Mohan (1972) classified the sciaenid fishes of India based on gas bladder structure and otoliths and listed 30 species under 14 genera. Talwar (op.cit.) also based his studies of the sciaenid fishes on structure of gas bladder.

In the present study 37 species belonging to 16 genus are described (Table 37). The family Sciaenidae is divided into 5 subfamilies, viz., Johninae, Kathalinae, Otolithoidinae, Sciaenae and Otolithinae. The subfamily Otolithoidinae is further divided into two tribes Macrospinosini and otolithoidini. The genus Johnius Bloch and Johnieops Mohan are included in the subfamily Johninae whereas the genus *Kathala* Mohan is in the Kathalinae which seems to be a specialised group. In the tribe Macrospinosini, *Macrospinosa* Mohan and in Otolithoidini the genera *Otolithoides* Fowler, *Panna* Mohan and *Bahaba* Herre are included. The subfamily Otolithinae is further divided into tribes Otolithini and Argyrosomini. The genera *Pterotolithes* Fowler, *Otolithes* Oken and *Chrysochir* Trewavas and Yazdani, *Pennahia* Fowler and *Atrobucca* Chu, Lo and Wu come under otolithini; *Argyrosomus* de La Pylaie, *Dendrophysa* Trewavas, *Nibea* Jordan and Thompson are placed in the tribe Argyrosomini. The main stock of sciaenae leads to the genus *Umbrina* with gas bladder devoid of tubules.

The gas bladders of subfamily Johninae have lateral arborescent tubules and antero-lateral expansion on each side. The first arborescent tubules of each side communicate to exterior through the pectoral arch. In otolithinae the lateral arborescent tubules vary in length. The genera *Johnius* and *Johnieops* seems to be closely related as their gas bladder and otoliths are more or less alike. However their sensory pores and dentition differ. The subfamily Kathalinae seems to be an aberrent off-shoot very closely related to the Johninae even though the arborescent tubules are reduced to one pair of short tubules the structure of otoliths is more or less similar to that of Johninae.

There may be only two pairs of short tubules as in Macrospinosa or a long pair of tubules as in Panna. In Otolithoides the tubules originate from the posterior end of gas bladder. In Nibea the arborescent tubules may be short whereas in Atrobucca the tubules are long, well developed and the gas bladder is rounded anteriorly without the antero-lateral expansions. The subfamily otolithoidinae presents various modifications in the structure of arborescent tubules.

The structure of gas bladder of Sciaenids seems to have evolved according to the ecological habitats. The species of the subfamily Johninae are benthic and hence they have inferior mouth, snout and lower jaw with well developed lateral line sensory pores and the gas bladder with lateral arborescent tubules of which the outer branch of the first tubule communicating the exterior through the pectoral arch. The subfamilies Kathalinae and Otolithoidinae occupy mostly mid-water and bottom layers feeding in these regions. Hence they have less developed arborescent tubules and poorly formed lateral line pores on snout and lower jaw. In these groups also the genus Panna occupy column and surface layers. The subfamily Otolithinae has radiated to different ecological niches such as bottom, column and pelagic layers. Dendrophysa and a few species of Nibea are bottom feeders whereas Otolithes, Pterotolithes, Chrysochir, Pennahia and Atrobucca feed on the column and surface layers.

The structure of otoliths (sagitta) also offers another basis of relationship between different genera. Kathalinae is related to Johninae as seen by the similarity of their otoliths. Similarly Otolithoidinae and Otolithinae are also related as they have elongated sagitta with shallow anterior and posterior depression (Plate VIII, fig.3).

The development of sensory pores on snout and lower jaw are mainly due to the benthic habit of the species. In the present study though importance is given to the internal structures such as gas bladder and otoliths external morphometric and meristic characters are also studied and given due consideration.

2. MATERIAL AND METHODS

Specimens were collected from trawl nets, gill nets and shore seines. They were preserved in 5% formalin and examined. Care was taken to select only intact specimens for the taxonomic studies. The specimens mentioned in the text were deposited in the Reference Collection Museum of the Central Marine Fisheries Research Institute, Mandapam Camp.

The terminology of Hubbs & Lagler (1957) was followed in describing the morphometric and meristic characters. In describing lateral line pores of snout and the gas bladder the terminology of Chu *et al* (1963) was adopted.

Standard length: Distance from most anterior part of head to base of caudal rays.

Height at dorsal origin: Greatest diamension at origin of first dorsal spine.

Height at anal origin: Greatest diamension of the body at origin of first anal spine.

Height at caudal peduncle: Least depth at caudal peduncle.

Head length: Distance from most anterior point of snout to posterior end of opercular membrane.

Predorsal length: Distance from tip of snout to base of first dorsal spine.

Eye diameter: The greatest distance across cornea between margins of eye-ball.

Snout length: Anterior most point of the snout to the front margin of the orbit.

Upper jaw length: Anterior most point of the premaxillary to the posterior most point of the maxillary.

Lower jaw length: Posterior end of mandible to its anterior tip.

Interorbital space: Least width between the orbits.

Dorsal spine length: Base of spine to its tip.

Pectoral fin length: Distance from extreme base of upper most ray to the farthest tip of fin.

Caudal fin: Caudal base to tip of caudal fin.

Lateral line scales (Ll): Number of scales from the shoulder girdle along the line terminating at end of hypural plate.

Lateral line scales (Ltr.): Rows of scales downwards from origin of dorsal fin to origin of anal fin; scales above the lateral line and below the lateral line are mentioned separately.

Gill rakers: The number of gill rakers of first arch; upper and lower limbs were taken separately indicating middle gill raker also.

Morphometric measurements were expressed in percentage of standard length, head length and eye diameter and their 'range' were also calculated.

Arithmetic mean, standard deviation, standard error and the percentage of coefficient of variation were found out by using the equations (1), (2), (3), (4).

$$\text{Mean } (\bar{X}) = \frac{x_1 + x_2 \text{ --- } x_n}{n} \quad .. \quad .. \qquad (1)$$

$$\text{Standard devision (S.D.)} = \sqrt{\frac{(\Sigma X)^2}{n} - \bar{X}^2} \quad .. \qquad (2)$$

$$\text{Standard error (S.E.)} = \frac{\text{S.D.}}{\sqrt{n}} \quad .. \quad .. \qquad (3)$$

$$\text{Coefficient of variation (C.V.)} = \frac{\text{S.D.}}{\bar{X}} \times 100 \quad .. \qquad (4)$$

If the percentage of coefficient of variation was above 10.0, then the character was considered to be a labile (variable) character. If it was above 15.0 then it was considered to be very labile or highly variable character. This variation may be due to the differences of their habitat or due to the difference between their size groups or due to racial characters. The meristic characters were also studied to understand this range of variation (Table 33-37).

FAMILY SCIAENIDAE

Body elongate, oblong, cleft of mouth oblique to horizontal, mouth terminal subterminal or inferior; snout may or may not overlap upper jaw; maxillary without the supplemental bone; premaxillary protractile, preopercle serrate or entire; teeth mostly minute with or without a row of enlarged teeth, canines may or may not be present; palate, vomer, pterygoid and tongue edentulous; nostribs two; subocular narrow; gill membrane separated, free from isthmus; gills four, slit behind fourth, pseudobranchiae present; branchiostegals seven; lateral line continuous extending to caudal fin; tubes frequently branched; bones of the skull cavernous, the muciferous system highly developed; snout and chin with sensory pores; lower pharyngeal separate or united with well developed teeth; opercle with two flat spines; vertebrae 24 to 30, otoliths large; gas bladder with or without well developed arborescent tubules; dorsal fin notched and divided as spinous and soft dorsal, latter usually longer; anal fin with two spines ventral fins thoracic, 1, 5; caudal fin usually not forked; with intertine with 2 convolutions; pyloric appendages feeble.

The sciaenids are an a important group of food fishes living mostly in warm seas except in Oceania. Most of the species are coastal forms while some estuaries and are found in the deeper parts of the continental shelf. Some of them grow to large size though many attain a size of about 30 cm only. Gas bladders of some of the species are used for making isinglass; most of the species are important food fishes and a few species offer good sport also.

These fishes are known as croakers, grunters or drums because they produce sounds; the sound is produced by the muscular action of the gas bladder. All the species are carnivors; they occupy poelagic, midwater and bottom regions;

Subfamily : Johninae

Gas bladder with 14-15 pairs of arborescent tubules; mental pores 5-6; gas bladder with antero-lateral expansion.

Synoptic key to the sub families of the fishes of the family Sciaenidae of India.

1. Gas bladder with more than 14-15 pairs of arborescent tubules; mental pores 5-6 .. 2
   Gas bladder with less than 3 pairs of arborescent tubules; mental pores ~~2~~-4 .. 3
2. Gas bladder with antero-lateral expansions .. Johniinae
   Gas bladder without antero-lateral expansions .. Otolithinae
3. Gas bladder with one or two tubules 4
   Gas bladder without tubules .. Sciaeninae
4. Sagitta elongate with shallow anterior and posterior groove ('Otolithes' type) .. Otolithoidinae
   Sagitta short with deep posterior groove ('johnius' type) .. Kathalinae

Synoptic key to the genera of fishes of the family Sciaenidae of India.

1. Gas bladder with antero-lateral expansions and arborescent tubules .. 2
   Gas bladder without anterolateral expansions, arborescent tubules may or may not be present 3
2. Lower jaw with five pores separated by fleshy margin, and with villiform band of teeth .. Johnius
   Lower jaw with five pores without fleshy margin, lower jaw with enlarged teeth .. Johnieops

3. Gas bladder simple without tubules .. Umbrina

Gas bladder with tubules .. 4

4. Gas bladder with one or two tubules .. 5

Gas bladder with more than 15 pairs of tubules .. 8

5. Gas bladder with short tubules anteriorly 6

Gas bladder with long tubules .. 7

6. One pair of tubules anteriorly .. *Kathala*

Two pairs of tubules anteriorly .. *Macrospinosa*

7. A pair of anterior tubules on each side extending to head and base of anal fin.. *Panna*

A pair of posterior tubules extending to head .. *Otolithoides*

8. Lower jaw with 2-4 mental pores .. 9

Lower jaw with 5-6 mental pores .. 10

9. Anal fin with 7-8 rays .. 11

Anal fin with more than 9 rays .. *Pterotolithes*

10. Jaws with well developed canines .. *Otolithes*

Jaws without canines .. *Pennahia*

11. Arborescent tubules long, mental pores not distinct .. 12

Arborescent tubules short mental pores distinct .. 13

12. Arborescent tubules on each side meet dorsally .. *Atrobucca*

Arborescent tubules do not meet dorsally .. *Argyrosomus*

13. Lower jaw with villiform teeth .. Dendrophysa
    Lower jaw with enlarged teeth .. 14

14. Upper jaw without canines .. Nibea
    Upper jaw with canines .. Chrysochir

KEY TO THE SPECIES OF SCIAENID FISHES OF INDIA

1	Lower jaw with one or two mental barbels	..	2
	Lower jaw without mental barbel	..	8
2	Lower jaw with one mental barbel	..	3
	Lower jaw with two mental barbel	..	7
3	Second dorsal fin with 24-28 rays	..	4
	Second dorsal fin with 30-34 rays, mental barbel minute, scales ctenoid, lower jaw with no enlarged teeth	..	Johnius macropterus
4	Body with narrow dark oblique bands; second dorsal, 1, 27-29; Ltr.7/12; anal spine half of length of head, scales ctenoid	..	Umbrina sinuata
	Body without narrow oblique bands	..	5
5	Body with ctenoid scales	..	6
	Body with cycloid scales, second dorsal with 1, 23-26;	..	Johnius dussumieri
6	Second anal spine 38-57% of head length, mental barbel 62-80% of eye, gas bladder without anterolateral expansion and with arborscent tubules, lower jaw teeth villiform	..	Dendrophysa russelli
	Second anal spine 26-28% of head length, mental barbel 20-27% of eye, nape with out a brown grey band	..	Johnius mannarensis
7	Second dorsal rays 23-24; second anal spine 45-52% of head length, gas bladder without antero-lateral expansions, lower jaw with enlarged teeth; barbles filiform	..	Nibea albida
	Second dorsal rays 25-29; second anal spine 19-32% of head length, gas bladder with antero-lateral expansion; barbels knob-like	..	Johnius elongatus
8	Canine teeth present	..	9
	Canine teeth absent	..	16

9	Canine teeth in both jaws	10
	Canine teeth in upper jaw only	13
10	Dorsal rays 20-21	*Otolithes versicolor*
	Dorsal rays 27-32	11
11	Anal fin with 10-11 rays	*Pterotolithus maculatus*
	Anal fin with 7 rays	12
12	Gill rakers 13-14 on lower limb of first arch; eyes 20-22% of head; lower canine 18-27% of eye	*Otolithes cuvieri*
	Gill rakers 8-10 on lower limb of first arch; eyes 15-20% of head; lower canines 28-55% of eye	*Otolithes ruber*
13	Dorsal rays 25-26; mental pores six; gas bladder with 25 well developed arborescent tubules	*Chrysochir aureus*
	Dorsal rays 28-44; mental pores 3-4; gas bladder with 2 pairs of tubules	14
14	Dorsal rays 28-29	*Otolithoides biauritus*
	Dorsal rays 31-44	15
15	Dorsal rays 31-35; gill rakers 57-66% in eye, Ltr. 12-15/14-16	*Panna microdon*
	Dorsal rays 40-44; gill rakers 66-100% in eye; Ltr.15-16/20	*Otolithoides pama*
16	Lower jaw with an inner row of enlarged teeth and well developed gill rakers	17
	Lower jaw with villiform teeth with poorly developed gill rakers	31
17	Mouth inferior	18
	Mouth terminal or subterminal	20
18	Body with 5 grey bands, second anal spine strong	*Nibea maculatus*
	Body without bands or spots; second anal spine weak	19

19 Height of body 26-30% in S.L.; upper
jaw 33-37% second anal spine 21-31%;
longest gill rakers 4-7% in eye,
G.R. 3-5/5-8 .. *Johnieops macrorhynus*

Height of body 29-35% in S.L.; upper
jaw 38-44% second anal spine
29-36% in head; longest gill rakers
11-25% in eye G.R. 5-6/11-13 .. *Johnieops osseus*

20 Body deeply coloured 21

Body not deeply coloured 23

21 Dorsal rays 23-25 .. *Nibea diacanthus*

Dorsal rays 26-30 22

22 Body dark grey with black oblique bands
Ltr.12-13/19-21; second anal spine
37-45% in head, gas bladder with
18 ~~22-28~~ arborescent tubules .. *Nibea semiluctousa*

Body hyaline with oblique dark band;
Ltr.8-10/11-12; second anal spine
54-63% of head length, gas bladder
with two pairs of short tubules .. *Macrospinosa cuja*

23 Axilla with well developed blotch; gill
rakers 9-11/19-22; gas bladder with
a pair of anterior tubules .. *Kathala axillaris*

Axilla without blotch; gill rakers
less than 8/16 24

24. Second anal spine strong, 42-60% of head.. 25

Second anal spine weak less than 40% of head .. 27

25 Gas bladder with one pair of anterior
tubules gill rakers 4-5/7-8; dorsal
rays 24-26%; anal spine 45-50%; Ltr.10/20.. *Bahaba chaptis*

Gas bladder wth more than 10 arborescent
tubules 26

26 Dorsal rays 24-25; second anal spine
42% of head length; G.R.5/13 .. *Nibea chui*

Dorsal rays 28-30; second anal spine
46-60% of head length; G.R.5/8 .. *Nibea soldado*

27 Gas bladder with antero-lateral.. expansions;lower jaw with distinct pores 28

Gas bladder without antero-lateral expansions; lower jaw with indistinct pores 30

28 Upper jaw with a pair of well developed anterior teeth; lower jaw teeth also well developed .. Johnieops vogleri

Upper jaw teeth not well developed .. 29

29 Inner row of lower jaw teeth moderately developed; second anal spine 16-30% of head .. Johnieops sina

Upper and lower jaw teeth feebly developed .. Johnieops dussumieri

30 Dorsal rays 27-28 .. Atrobucca nibe

Dorsal rays 21-27 31

31 Caudal fin truncated, Ltr.7-8/14; dorsal rays 21-26 .. Pennahia macrophthalmus

Caudal fin cuneate; Ltr.9-10/18; dorsal rays 27 .. Nibea bleekeri

32 Lateral line with a white band, body dark .. Nohnius carutta

Lateral line without a white band .. 33

33 Body dark grey, tips of pelvic fins black, lower lip well developed; second anal spine 39-49% of head; Ltr.8-9/1/12-15 .. Johnius belengeri

Body lightly coloured 34

34 Anal spine strong, 35-56% of head length.. 35

Anal spine weak, 25-32% of head length .. Johnius glaucus

35 Ltr. 7-8/12-14; height 24-29% of standard length;dorsal rays 25-27; anal spine 43-56% of head .. Johnius coitor

Ltr.5-6/9-12; height 28-34% of standard length; dorsal rays 22-29; anal spine 35-50% of head .. Johnius carouna

Johnius Bloch

Johnius Bloch, 1793. Natur. Ausland. Fische, pt.7:132; Fowler, 1933. Bull.100. U.S. nat. Mus.,12:370-371;-- Weber and deBeaufort, 1936. Fish. Indo-Austr.Archipel. 7:526;-- Collignon, 1959, Bull.Inst.Oceanogr. Monaco, No.1155:7-8;-- Trewavas, 1962, Ann. Mag. nat. Hist., (13)5:173;-- Chu, Lo & Wu, 1963, Monogr. Fish China: 19-20;-- Yazdani, 1966, J. Zool. Soc. India, 15:65 (1963);-- Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65(2):36-39;-- Mohan, 1972, Indian J. Fish., 16: 82-98.

Apeches Gistel, 1848, Naturg. Thierr: 9 (Type: Johnius carutta Bloch).

Wak Lin, 1938, Lingnan Sci. J., 17:378 (Type: Bola coitor Hamilton, type locality: Ganges);-- Chu, Lo and Wu, 1964, Monogr. Fish. China:27;-- Talwar, 1971, J. mar. biol. Ass. India, 9:324-328.

Bola Hamilton, 1822, Fishes of Ganges:78 (Type: Bola coitor Hamilton, type locality: Ganges; designated by Jordan and Thompson, 1911;-- Jordan and Stark, 1917, Ann. carneg. Mus., 11:451-452.

Diagnosis: Gas bladder with an antero-lateral expansions lateral arborescent tubules 11 to 15, the first tubule extends through transverse septum into head where it immediately divides into two, inner division branching under the skull, the outer extending laterally to end in a palmate tip under the skin of the branchial wall covering the supracleithrum, otoliths (sagitta) enlarged anteriorly, pointed posteriorly with an anterior inner indistinct depression and with shallow marginal groove posteriorly forming a deep pit;snout with three rostral pores and five marginal pores; lower jaw with five mental pores; mouth inferior, snout over lapping lower jaw, teeth differentiated on upper jaw and uniformly villiform on lower jaw; a median mental barbele may or may not be present. D. IX-X, 1, 22-34.

General distribution: Indo-Pacific and tropical Atlantic.

Type: *Johnius carutta* Bloch.

Remark: This genus is represented by nine species in India.

Johnius carutta Bloch

(Plate I, Fig.1a)

Johnius carutta Bloch, 1793, *Natur. Ausland. Fische*, pt.7:133, pl.356., (Type locality: Tranquebar);-- Schneider, 1801, *Syst. Ichth. Bloch*:74 (Tranquebar);-- Cantor, 1849, *J. Asiat. Soc. Bengal*, 18:1028 (Pinang);-- Bleeker, 1874 *Verh. Kon. Akad. Wet. Amsterdam*, 14:48;-- Jordan and Stark, 1917, *Ann. Carnegie Mus.*, 11:453 (Ceylon);-- Fowler, 1926, *J. Bombay nat. Hist. Soc.*, 30:10 (Bombay); 1933, *Bull 100 U.S. natn. Mus.*, 12:384 (China);-- Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archipel.*, 7:529;-- Munro, 1955, *Marine and fresh water fishes of Ceylon*: 555;-- Chu, Lo and Wu, 1963. *Monogr. fishes of China*:

26;-- Dutt and Thankam, 1968, J. Bombay nat. Hist., 65:337 (Waltair). - Fisher and Whitehead, 1974 F.A.O. sp. ident. Sheets Fish Purposes, 3 Sciaen John 2.

Labrus carutta Lacépède, 1802, Hist. Nat. Poiss. 3:447.

Corvina carutta Cuver, 1830, Hist. Nat. Poiss., 5:124 (Pondicherry, Malabar);-- Day, 1865, Fishes of Malabar: 51;-- Karoli, 1881, Termesz. Fuzetek, Budapest, 5:159 (Canton).

Sciaena carutta Day, 1878, Fishes of India pt.2:192, pl.44, fig.1 (Madras); 1889, Fauna Br. India, Fishes,2:122.

Material:

5 specimens: Mandapam; 200 mm, male,7-10-68; 174 mm, female, 11-7-69; 191 mm, male, 17-8-70; 154 mm, male, 18-1-69; 132 mm, male, 7-10-70. 2 specimens: Madras; 186 mm, 162 mm, female, 10-12-68; 4 specimens: Kakinada, 154 mm, 155 mm, 110 mm, 138 mm, males, 8-11-68. 2 specimens Tuticorin; 133 mm, female, 3-7-68; 126 mm, male, 7-8-68. 1 specimen: Puthalam (near Cape Comorin), 202 mm, female 4-8-67. 2 specimens: Vizhinjam, 179 mm, male, 7-8-68.

Description: D. X, 1, 27-30; P.17-18; A.II, 7; C.17; v.1,5. Ll.48-50; Ltr.6-8/1/13-16. G.R.3-4/1/6-8.

Body spindle shaped, head blunt, interorbital space flat; mouth inferior, jaws extend to middle of eye, cleft of mouth horizontal, snout swollen, overlapping premaxillaries;

upper jaw with an outer row of enlarged teeth and an inner row of villiform teeth, lower jaw with a band of villiform teeth; pharyngeal teeth well developed; prēopercle serrated; tip of snout with three distinct rostral pores; marginal pores five, outer marginal pores cleft-like, inner marginal pores distinct and median marginal pore on a median lobe; lower jaw with five mental pores: outer and inner mental pores distinct and a median mental pore at tip of an elevated projection; gill rakers very short and stumpy and dentate on one side; cycloid scales on cheeks, preopercle and nape; Weakly ctenoid scales on rest of body; lateral line appears as a white streak orginating above opercle and terminating at tip of caudal fin; lateral line scales with bifurcated branches.

Gas bladder tapers posteriorly extending to base of anal fin; arborescent tubules well developed, short, about fifteen on each side; otoliths (sagitta) 'Johnius type'; spines of first dorsal fin not strong, second dorsal spine longest, first dorsal connected to second dorsal through a low membrane; scales absent over the base of second dorsal and anal fins; first ray of pelvic fins elongated; second anal spine not robust; ventral rays of caudal elongated.

Body deep grey to pale grey dorsally, first dorsal deep grey, second dorsal, caudal anal and pectoral fins pale grey, lateral line with a white streak.

(Detailed morphometric measurements and body proportions are given in Table 1).

<u>General distribution</u>: India, Ceylon, Penang, Indo-China, Hong Kong, China, Sumatra.

<u>Remark</u>: This species can be easily identified by the white streak along the lateral line.

<u>Johnius glaucus</u> (Day)
(Plate I, Fig.2a)

<u>Sciaena dussumieri</u> (not Cuv. & Val.) Day, 1865, <u>Fishes of Malabar</u>: 53.

<u>Sciaena glaucus</u> Day, 1878, <u>Fishes of India</u>, pt.2:192, pl46, fig.2.

<u>Sciaena glauca</u> Day, 1889, <u>Fauna Br. India, Fishes, 2</u>: 112.

<u>Johnius glaucus</u> Fowler, 1926, <u>J. Bombay nat. Hist. Soc.</u>,30, <u>4</u>:10; 1927, 32, no.2:260; 1931, <u>Proc. Acad. nat. Sci. Philad</u>: 447 (Singapore); Mohan 1972, <u>Indian J. Fish.</u>, <u>16</u>: 82-95 (Bombay).

<u>Material</u>:

5 specimens: Bombay; 177 mm, female, 10-3-69;
187 mm, female, 28-10-72; 176 mm, female, 28-10-72;
141 mm, male, 28-10-72; 140 mm, male, 28-10-72;
3 specimens: Veraval; 220 mm, female, 28-10-72;
225 mm, female, 4-11-72; 200 mm female, 4-11-72.

<u>Description</u>:

D. X, I, 28-30; P.17-18; A.II, 7; L1.47-48;
Ltr.J-6-7/1/12; G.R.5/1/10-13.

Body spindle shaped, head rather blunt, dorsal profile gradually ascending, snout overlapping premaxililaries, lower jaw slightly shorter than upper jaw, cleft of mouth oblique extending to half of eye; eyes large, snout margin lobulated at the outer marginal pore; upper jaw with an outer row of enlarged teeth and inner rows of villiform teeth, lower jaw with a broad band of villiform teeth; pharyngeal teeth present; preopercle serrated; scales cycloid on opercle, preopercle serrated; scales cycloid on opercle, preopercle and cheeks, ctnoid scales on body snout with 3 rostral pores and five marginal pores, snout margin with a deep cleft at outer marginal pores, a shallow cleft at inner marginal pore and the median marginal pore; lower jaw with five mental pores. Gas bladder Johnius type with 14-15 arborescent tubules; otolith 'johnius type'. Lateral line orginates above opercle terminating at caudal tip; first dorsal spine short, second and third more or less of same height, last spine of first dorsal and first spine of second dorsal of same height, caudal fin cuneate, second anal spine short not very strong and $\frac{2}{3}$ of first anal ray and equals to eye; first rays of pelvics filiform; minute scales on base of second dorsal and anal fins; gill rakers moderately developed rather flat with well developed simple curved spines on both sides.

Upper two third of first dorsal black, opercle with blue blotch; branchial and body cavities black, body dorsally grey and ventrally pale.

(Detailed morphometric measurements and proportions are given in Table 2).

__Distribution:__

North west coast of India.

Remarks:

Fowler (1933) synonymised this species with Corvina dussumieri Cuver, 1830 which belongs to genus Johnieops Mohan.

Johnius coitor (Hamilton)

(Plate I, Fig. 3a)

Bola coitor Hamilton, 1822, Fishes of Ganges: 75, 368, pl.27, Fig.24 (Ganges).

Corvina coitor Cuvier, 1830, Hist. Nat. Poiss., 5:116 (Ganges, Irawaddi estuaries);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:301, (China, Calcutta);-- Dunker, 1904, Mitt. Naturh. Mus. Hamburg., 21:154 (1903) (Kuala Selangor).

Johnius coitor Blyth, 1860, J. Asiat. Soc. Bengal, 29:141 (Sitang River);-- Fowler, 1933, Bull. 100 U.S. nat. Mus. 12:405;-- Talwar and Shetty, 1971, Proc. Indian Acad. Sci., 74:74-81;-- Fisher & Whitehead, 1974. F.A.O. Sp. ident. Sheets Fish. Purpose 3: Sciaen. John 2.

½ Sciaena coitor Day, 1878, Fishes of India, pt.2:187, pl.46, fig.3 (Irrawadi);-- Day, 1889, Fauna Br.Indian, Fishes, 2:115, fig.49;-- Shaw and Shebbeare, 1937, J. Roy. Asiat. Soc. Bengal, 3:115, fig.121;-- Srivastava, 1968, Fishes of Eastern Utter Pradesh: 131, fig.77.

Sciaena (Corvina) nasus Steindachner, 1866, Verh. Zool. bot. Ges. Wien, 16:771, pl.15, fig.1 (Calcutta).

Wak coitor Lin, 1938, *Ling. Sci. J.*, 17:378;— Chu, Lu and Wu, 1963, *Monogr. Fish. China*: 28, fig.14.

Material:

12 specimens: Calcutta, 171 mm, female, 17-11-68; 177 mm, female, 17-11-68; 149 mm, male, 10-11-68; 146 mm, male, 11-11-68; 139 mm, female, 11-11-68; 137 mm, female, 11-11-68; 134 mm, male, 10-11-68; 130 mm, male, 10-11-68; 146 mm, male, 10-11-68; 125 mm, male, 10-11-68; 110 mm, male, 10-11-68; 116 mm, male, 10-11-68.

Description:

D. IX-X, I, 25-29; P.16-17, A.II, 7; C.17.Ll.49-51; Ltr.7-8/1/12-14; G.R.4-5/1/9-12.

Body spindle shaped, head rather pointed, dorsal profile convex; lower jaw shorter than upper, cleft of mouth horizontal extending to middle of eye; mouth inferior, snout projecting over the upper jaw; upper jaw with enlarged outer row and minute inner row of teeth; lower jaw with a band of villiform teeth, pharyngeal teeth well developed; preopercle serrated; snout with three rostral pores, and marginal pores; margin of snout well indented at the pores, median marginal pore on a lobe;lower jaw with five mental pores, marginal pores slit like, median mental pore distinct with a fleshy pad. Lateral line extends to tip of caudal fin, lateral line scales with bifurcated tubes.

Gas bladder 'johnius type', tapering posteriorly and extending to anal base, arborescent tubules eleven, well developed, last branch elongated, otolith (sagitta) 'johnius' type.

Cycloid scales on cheeks and preopercle; ctenoid scales on opercle, nape and other parts of body; scales strongly ctenoid on body; first dorsal with strong spines, second and third spines longest, dorsal fin notched shallowly, membrane of first dorsal tough; second anal spine robust, pointed, about $\frac{3}{4}$ of first anal ray; first ray of pelvic fins filiform; 2 rows of minute scales at the base of second dorsal and anal fins; gill rakers short, stumpy and dentate.

Opercle with a steel blue blotch, body dorsally light grey, ventrally pale, upper $\frac{1}{3}$ of first dorsal grey, margin of caudal fin grey.

(Detailed morphometric measurements and proportions are given in Table 3).

General distribution:

India, Burma, Malay Penninsula and Indo-china; in estuaries of rivers Ganges and Irrawadi, ascending the rivers.

Remarks:

The type species of Wak Lin, 1938 is Johnius coitor Hamilton. As 'coitor' belongs to Johnius Bloch, the genus Wak Lin is not valid and a genus Johnieops has been proposed (Mohan, 1972) for those species of subfamily Johniinae with enlarged lower jaw teeth, and subterminal mouth. Babu Rao and Sinha (1968) recorded Johnius novaehollandae from Calcutta. But the higher dorsal fin ray count (25-30) instead of 25 in *J. novaehollandae* and the length of second anal spine indicate that the above authors were describing *J. coitor* which occurs there commonly, it was not recorded by them.

Johnius mannarensis Mohan

(Plate I, Fig. 4a)

Johnius mannarensis Mohan, 1969, *J. Mar. Biol. Ass. India*, *11*(1&2):320.323;-- Type locality Off Pamban, Gulf of Mannar;-- 1972, *Indian J. Fish.*, *16*:85-97. ~~Fishery~~ Fischer & Whitehead, 1974, F.A.O. Sp. ident. Sheets Fish Purposes, 3: Sciae 6.

Material:

3 specimens: Pamban (Gulf of Mannar) 192 mm, female, 10-10-68; CMFRI No.149; 209 mm, female, 10-10-68; CMFRI No.150A; 145 mm, male, 7-3-68; CMFRI No.150B.

Description:

D.X, I, 27; A.II, 7; P. 15; Ll.44-46; Ltr.7/1/10-12; gill rakers 5/1/10.

In standard length depth 26.7-28.0; head length 29.3-31.7; In head, eye 19.5-20.0; snout 20.6-32.77; interorbital space 25.0-26.3; caudal peduncle depth 29.2-34.8; length of second dorsal spine 60.0-64.5; third dorsal spine 56.5-62.5; second anal spine 29.0-34.3; length of pectoral fin 62.5-66.6; pelvic fin 53.6-66.6. In eye, snout 133.3-154.0, mental barbel 20.0-27.2 (measurements in percentages).

Snout overlapping lower jaw, mouth inferior, cleft of mouth horizontal; three distinct rostral porês at tip of snout; marginal pores five, outer marginal pores slit-like, inner marginal pores cleft-like, free margin of snout lobulated; lower jaw with five distinct mental pores, outer and inner mental pores deep, median mental pore at base of a short solid mental barbel; margin of preopercle and opercle not serrated; upper and lower jaws with a band of villiform teeth, outer row of upper teeth enlarged, lower jaw with no enlarged teeth; scales cycloid on cheek, preopercle and opercle, but ctenoid on body; gas bladder 'johnius type'with 13-15 tubules; sagitta also 'johnius type'; dorsal spines strong, second spine longer than first, third slightly shorter than second; second anal spine half as long as soft rays; caudal fin rhomboid on lower side; gill rakers rudimentary short and stumpy.

Dorsally dusky and pale ventrally, first dorsal grey, second dorsal light grey, pectoral and caudal fin lightly mottled.

Habitat:

Trawling grounds off Pamban in the Gulf of Mannar.

Relationship:

The general body form, number of lateral line and lateral transverse scales and nature of barbel bring J. mannarensis close to Johnius dussumieri. However, it differês from the latter in having ctenoid scales, a shorter mental barbel, shorter first dorsal fin, and in the colouration.

Johnius macropterus (Bleeker)

(Plate II, Fig.1a)

Umbrina macropterus Bleeker, 1853, Nat. Tijds. Nederland India, 4:254 (Sumatra).

Umbrina macroptera Gunther, 1860, Cat. Fish. Br. Mus., 2:279;— Day, 1878, Fishes of India, pt.2:182 (Madras); 1889, Fauna Br. India, Fish., 2:108 (Madras);— Jordan and Stark, 1917, Ann. Carnegie Mus., 11:454 (Ceylon);— Barnard, 1927, Ann. S. Afr. Mus., 21, pt.2:581 (Natal).

Sciaena macropterus Bleeker, 1874, Verh. kon. Akad. Wet. Amsterdam, 14, No.4:60 (Sumatra);— Munroe, 1955, Marine and fresh water fishes of Ceylon:153.

Sciaena macroptera Fowler, 1904, J. Acad. Nat. Sci., Philad, ser.2, 12:530 (Padang);— Fowler, 1925, J. Bombay Nat. Hist. Soc., 30:320 (Bombay); 1933, Bull. 100 U.S. Nat. Mus., 12:412. (Java, Bombay, Sumatra).

Johnius macropterus Fowler, 1930, Proc. Acad. Nat. Sci. Philad., 1929, 652; Mohan, 1972, Indian J. Fish., 16:82-98. (Gulf of Mannar).— Fisher & Whitehead, 1974, F.A.O. Sp. ident. Sheets Fish Purposes 3: Sciaen.6.

Dendrophysa macroptera Trewavas, 1964, Copeia:111;— Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc.,65:343 (Waltair).

Blythia macroptera Talwar, 1971, J. Inland Fish. Soc. India, 3:22-24.

Material:

5 specimens: Mandapam, Palk Bay, 154 mm, female, 10-11-71; 112 mm, male, 14-8-69; 131 mm, male, 16-9-69; 133 mm, female, 18-10-69; 122 mm, male, 17-11-69. 5 specimens: Pamban Gulf of Mannar, 132 mm, male, 17-11-69; 160 mm, female, 10-3-68; 156 mm, female, 7-6-70; 135 mm, male, 13-8-69; 157 mm, female, 10-6-71. 2 specimens: Tuticorin, 130 mm, female, 6-3-69; 139 mm, female, 13-8-69.

Description:

D.IX-XI, I, 30-34; P.17-18; A.II, 7; C.16-17; Ll.45-48; Ltr.4-5/1/10-11; G.R.4-5/1/8-11.

Body spindle shaped, snout not pointed, interorbital space slightly convex, mouth inferior, cleft of mouth extending to middle of eye; snout projecting beyond upper jaw; eyes small; upper jaw with an outer row of enlarged teeth and an inner row of villiform teeth, lower jaw with a band of villiform teeth; pharyngeal teeth present; cycloid scales on cheeks, preopercle and opercle, ctenoid scales on body, base of second dorsal and anal fins with minute scales.

Snout with five rostral pores; and five marginal pores, outer marginal pore distinct, slit-like, inner marginal cleft-like, the median marginal pore triangular, margin of snout not lobulated; lower jaw with five mental pores, the median mental pore at the base of a minute, solid mental barbel. Gas bladder 'Johnius' type with 15-16 arborescent tubules; otoliths 'Johnius' type; lateral line originates above the gill opening and terminates at tip of caudal fin; lateral line scales ith tubules; first dorsal spine minute, second dorsal spine as long as third, last spine of first dorsal shorter than first spine as long as third, last spine of first dorsal shorter than first spine of second dorsal, first and second dorsal connected by a shallow membrane; second anal spine not very strong 1.5 of eyes; first ra s of pelvic fins filiform, caudal fin cuneate. Gill rakers short, stout and dentate on one side.

(Detailed morphometric measurements and proportions are given in the Table 4).

Body dark grey to pale grey, first dorsal fin dark grey, margin of other fins grey.

General distribution:

Natal, West and East Coasts of India, Ceylon, Sumatra and Java.

Johnius belangerii (Cuvier)

(Plate II, Fig.2a)

Corvina belengerii Cuvier, 1830, *Hist. Nat. Poiss.*, *5*:120 (Malabar).

Corvina belangerri Valenciennes, 1834, Voy. Ind. Orient. Belanger, Zool:357. (East Indies);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:3[illegible]3 (Pinang);-- Day, 1865, Fishes of Malabar:54;--.

Corvina belengeri Day, 1870, Proc. Zool. Soc. London: 684 (Andamans).

Corvina belangeri Borodin, 1930, Bull. Vanderbilt mar. Mus., 1, art.2:53 (India).

Sciaena (Corvina) belangeri Steindachner, 1866, Verh. Zool. bot. Ges. Wien, 16:771 (Calcutta).

Sciaena belengeri Day, 1878, Fishes of India, pt.2:191, pl.44, fig.5 (Bombay).

Sciaena belangeri Day, 1889, Fauna Br.India,2:120 (New Guinea).

Sciaena belangerii Norman, 1922, Ann. Mag. Nat. Hist., (9)9: 321 (Natal).

Johnius belengeri Cantor, 1850, J. Asiat. Soc. Bengal, 18, pt.2:1047 (1849), (Malay Peninsula);-- Weber and de Beaufort, 1936, Fish. Indo-Austr.Archipel.,7:533.

Johnius belengerii Fowler, 1933, Bull. 100 U.S. nat. Mus., 12:382 (Bombay);-- Lin, 1934, Ling. Sci. J., 13:681 (Fukien);-- Smith, 1953, The Sea fishes of S.Africa: 226 (Natal);-- Chu, Lo & Wu, 1963, Monograph of fishes of China:24-25;-- Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65:338-339 (Waltair, India).

Johnius dussumieri Wang (not Cuvier), 1935, Contr. Biol. lab. Sci. Soc. China, 10, no.9:459 (Shantung).

Johnius belangeri Fowler, 1927, *J. Bombay nat. Hist. Soc.*, *32*:260.

Corvina lobata Cuvier, 1930, *Hist. Nat. Poiss.*, *5*:122, pl.107 (Malabar); Gunther, 1860, *Cat. Fish. Br. Mus.*, 2:304.

Johnius belangerii Fisher & Whitehead, 1974, F.A.O. sp. ident. Sheets Fish Purposes 3: Sciaen. John.

Material:

5 specimens: Calcutta, 211 mm, female, 18-11-68; 142 mm, female, 15-11-68; 148 mm, male, 15-11-68; 163 mm, female, 15-11-68; 130 mm, female, 15-11-68: 1 specimen, Kakinada: 102 mm, male, 5-12-69: 6 specimens: Pamban (Gulf of Mannar), 191 mm female, 12-11-69; 190 mm, female, 6-12-70; 137 mm, female, 10-12-70; 127 mm, female,4-7-69; 147 mm, male, 8-9-70; 177 mm, female, 18-5-68; 2 specimens: Calicut: 138 mm, female, 16-6-69; 135 mm, female, 16-6-69.

Description:

D.IX-X, I, 27-31; P.16-18; A.II, 7; C.17; Ll. 47-49; Ltr.8-9/1/12-15; G.R.3-4/1/8-9.

Body spindle shaped, upper jaw longer than lower; cleft of mouth almost horizontal, maxillary extending to middle of eye; mouth inferior, snout projects over premaxillaries, upper and lower lips rather broad, eyes above the level of cleft of mouth; upper jaw with an outer row of enlarged teeth and an inner row of villiform teeth; lower jaw with a band of villiform teeth, pharyngeal teeth well developed; preopercle serrated.

Snout with five rostral pores, five well developed marginal pores; lower jaw with five well developed mental pores; gas baldder 'johnius type' with 14-15 arborescent tubules; otoliths 'johnius type'. Lateral line originates above opercle, terminating at tip of caudal fin. Lateral line scales with fiburcated tubules.

Cycloid scales on preopercle and cheeks, ctenoid scales on other parts of the body; minute scales at base of dorsal and anal fins, first dorsal fin membrane tough, spines robust; dorsal fin shallowly notched, second anal spine stout and strong, first rays of ventrals filiform; pectoral fin short; caudal fin rhomboid; gill rakers short, stumpy and dentate towards the tip.

Body pale grey to dark grey; tip of ventral, anal and caudal fins dark grey; colour varies in different localities; ventral, anal, caudal and dorsal fin tips of specimens from Malabar coast are very dark grey whereas that of Gulf of Mannar specimens light grey.

(Detailed morphometric measurements and proportions are given in Table 5).

<u>Remark:</u>

The dark grey tips of the fins and higher lateral transverse counts makes this species easily identifiable.

<u>General distribution:</u>

Natal, India, Andaman, East Indies, China and Philippines.

pores well developed, snout margin deeply lobulated, median marginal pore distinct on a median lobe (in larger specimens it communicates with the snout margin); lower jaw with five mental pores; gas bladder 'johnius type', arborescent tubules 15, otoliths 'johnius type'.

Scales on opercle, preopercle and body ctenoid, cycloid scales on cheeks; lateral line originates above opercle and terminates at tip of caudal fin; first dorsal spine minute, second and third spines longest, dorsal fin deeply notiched, last spine of first dorsal shorter than first spine of second dorsal; spines strong, membrane tough; base of second dorsal and anal with rows of scales; caudal fin rhomboid, second anal spine strong, two third of first anal ray and 1.75 of eye diameter, first rays of pelvic fins filiform; pectoral fins short, gill rakers thin, dentate on one side.

Body grey dorsally and hyaline to light grey ventrally. First dorsal, second dorsal and caudal light grey. Opercle with a light grey blotch. Pectoral and anal fins hyaline. Body colour varies from light grey to deep grey.

(Detailed morphometric measurements and proportions are given in the Table 6).

General distribution:

East and West coasts of India.

Remark:

The specimens collected from Mandapam was compared with the holotype at the Paris Natural History Museum, Paris, France by Dr. E. Trewavas of British Museum.

Johnius dussumieri (Valenciennes)

(Plate II, Fig.4a)

Umbrina dussumieri Valenciennes, 1833, Hist. Nat. Poiss., 9:481 (Coromandal, type locality);— Gunther, 1860, Cat. Fish. Br. Mus., 2:278;— Day, 1878, Fishes of India, pt.2:183, pl.43, fig.2-3;— 1889, Fauna Brit. India Fishes., 2:110;— Gilchrist and Thompson, 1917, Ann. Durban Mus., 1, No.4:351.

Sciaena dussumieri Bleeker, 1874, Verh. kon. Akad. wet. Amsterdam, 14:56 (East Indies, Singapore);— Fowler, 1933, Bull. 100 U.S. Nat. Mus., 12:412 (Philippines, Bombay, Natal);— Weber and de Beaufort, 1936, Fish. Indo-Austr. Archepel., 7:542;— Smith, 1950, Sea Fishes of South Africa:227 (Natal);— Monroe, 1955, Marine and Fresh Water Fishes of Ceylon:153.

Sciaena dussumieri Fowler, 1926, J. Bombay Nat. Hist.Soc., 30: 778 (Bombay).

Umbrina amblycephalus Bleeker, 1855, Nat. Tijds Nederland. Indie, 8:412 (Ambonia);— Gunther, 1960, Cat. Fish. Br. Mus., 2: 278;— Kner, 1868;— Karoli, 1881, Termtsz. Fuzetek, Budapest, 5:159 (Canton).

Johnius amblycephalus Chu, Lo and Wu, 1963, Monograph fishes of China: 21 (China).

Umbrina fuscolineata von Bonde, 1923, Fish. mar. surv. S.Afr. sp. Rep. 1:15, pl.4 (Natal);-- Barnard, 1927, Ann. S.Afr. Mus., 21, pt.2:577 (Natal, Zululand).

Dendrophysa dussumieri Trewavas, 1964, Copeia:109;-- Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65:340-

Blythya dussumieri Talwar, 1971, J. Inland Fish. Soc. India, 3: 22-24.

Johinus dussumieri Mohan, 1972, Indian J. Fish., 16:85-98. Fischer & Whitehead 1974, F.A.O. Sp. ident. Sheets Purposes, 3. Sciaen. 4.

Material:

6 specimens: Mandapam, 197 mm, female, 10-6-69;

82 mm, male, 9-7-68; 168 mm, female, 10-3-69; 135 mm, male, 18-5-67; 186 mm, female, 18-5-69; 131 mm, female, 11-6-70; 139 mm, male, 10-7-70; 121 mm, male, 10-8-70. 1 specimen: Pamban, 163 mm, female, 11-8-70. 1 specimen; Rameswaram, 135 mm, female, 10-8-70. 4 specimens: Tuticorin, 185 mm, female, 10-7-68; 147 mm, male, 10-7-68; 116 mm, male, 10-8-67; 195 mm, male, 10-7-68; 116 mm, male, 10-8-67; 195 mm, male, 10-7-68. 2 specimens: Madras, 176 mm, female, 10-11-68; 232 mm, female, 11-11-68.

Description:

D.X-XI, I, 23-26; P.15-17; A.II, 7; C.16-17; Ll.48-51; Ltr.7-9/1/14-17; G.R.3-4/1/6-8.

Body spindle shaped, dorsal profile convex; lower jaw shorter than upper jaw, maxillary extending beyond orbit, mouth inferior; snout projecting beyond premaxillaries, margin of snout indented. Eyes large, placed above cleft of upper jaw; upper jaw with an outer row of enlarged teeth and inner rows of villiform teeth; lower jaw with a band of villiform teeth (some teeth are molar like in large specimens); canines absent; pharyngeal teeth well developed; preopercle serrated; snout with three rostral pores and five marginal pores; lower jaw with five mental pores; median mental pore at the base of a solid barbel; gas bladder Johnius type, arborescent tubules 14-15, sagitta 'Johnius' type; lateral line originating above the opercle and terminating at tip of caudal fin; lateral line scales with branched tubes; scales on head and body cycloid, a row of minute scales at second dorsal base; second dorsal spine of first dorsal fin long, filiform, third dorsal spine as long as second spine; dorsal fin notched shallow (Elongation of second dorsal spine is more marked in smaller specimens), caudal fin biconcave. Gill rakers short, stumpty and dentate.

Dark grey to pale grey; first dorsal dark grey; caudal anal and pectoral fins with grey tinges; body pale grey ventrally.

(Detailed morphometric measurements and proportions are given in the Table 7).

<u>General distribution</u>:

Natal, Zululand, Mekaran, India, East Indies, Philippines, Indo-China, China.

<u>Remarks</u>:

Chu, <u>et al</u> (1963) used the second available name 'Amblycephalus' Bleeker, 1874, for <u>J. dussumieri</u> (Val), under the impression that '<u>dussumieri</u>' is preoccupied by <u>Johnius dussumieri</u> (Cuvier, 1830). But '<u>dussumieri</u>' Cuvier (<u>Corvina dussumieri</u> Cuvier, 1830) is a species without mental barbel and with enlarged lower jaw teeth. Hence it should be placed in <u>Johnieops</u> Mohan and the name '<u>dussumieri</u>' is available to <u>Sciaena dussumieri</u> Valenciennes, 1833. Talwar (1971) created a genus <u>Blythia</u> based on the presence of a barbel. Since this character is not considered as a generic feature in the present study, the genus <u>Blythia</u> Talwar is not considered to be valid.

<u>Johnius elongatus</u> Mohan

(Plate III, Fig.1a)

<u>Johnius elongatus</u> Mohan, 1975, <u>Matsya</u>, <u>1</u>:19-25.

<u>Material</u>:

6 specimens: Veraval, 197 mm (total length), female, 2-11-72; 205 mm, male, 230 mm, female; 250 mm, male; 131 mm, male; 245 mm, male. 1 specimen: Mangalore, 127 mm, female, 20-11-72. 1 specimen: Bombay, 190 mm, female 27-11-72.

Description:

D.X-XI, I, 25-29; P.16-17; A.II, 7; C.17;
Ll.48-49; Ltr.6-7/1/11-14; G.R.4-5/6-7.

Body spindleshaped, elongate, head pointed, dorsal profile ascends gradually; maxillary concealed, cleft of mouth horizontal not reaching middle of eye; eyes small, much above the level of mouth; snout prominent, projecting well beyond premaxillaries free margin deeply lobulated, upper jaw with outer row of slightly enlarged teeth and inner rows of villiform teeth; lower jaw with a uniform band of villiform teeth, pharyngeal teeth poorly developed; preopercle feebly serrated; scales ctenoid on body, opercle, preopercle and cheeks; lateral line scales without branched tubules; snout with three rostral pores and five marginal pores, outer marginal pores deeply indented; lower jaw with five mental pores, median and inner mental pores rimmed by a fleshy pad; a pair of short, solid mental barbels at the posterior margin of inner mental pores; gas bladder 'johnius type' with 15 arborescent tubules, otolith also of 'johnius type'; second and third dorsal spines longest, membrane weak; caudal fin ~~xx~~ cuneate; first rays of pelvic fins filiform; gill rakers minute, stumpy and poorly developed.

Dorsally grey, ventrally pale; upper portion of first dorsal dark grey. Margin of second dorsal and anal fins black.

Detailed morphometric measurements and proportions are given in the Table 8.

<u>General distribution</u>:

West coast of India.

<u>Remarks</u>:

J. elongatus can be differentiated from other species by the presence of two minute knobs on lower jaw and elongated body.

Johnieops Mohan

Johnieops Mohan, 1972, *Indian J. Fish.*, **16**:82-98.

<u>Diagnosis</u>:

Gas bladder with antero-lateral expansions (hammerhead shaped), lateral arborescent tubules 12-16. First tubule extends through transverse septum into head where it immediately divides into inner division branching under the skull, the outer extending laterally to end in a palmate tip under the skin of the branchial wall covering the supracleithrum. Otolith 'Johnius type'; enlarged anteriorly and tapering posteriorly with a shallow anterior depression on inner lateral side, marginal groove deep snout with three rostral pores, five marginal pores, free margin of the snout not indented deeply, lower jaw with five mental pores; no fleshy pad between the pores; mouth oblique or horizontal; upper jaw may or may not over lap lower jaw, teeth well differentiated in both jaws. D.X, I, 27-31.

Type:

Otolithus voglerI Bleeker

General distribution:

East Coast of Africa, Arabian coast, India, East Indies, China, Philippines, Japan.

Remark:

This genus is represented by six species from India. It is very close to Johnius Bloch but differs from it in having differentiated teeth and less, developed lateral line pores on snout and lower jaw.

Johnieops vogleri (Bleeker)

(Plate II, Fig. 2a)

Otolithus vogleri Bleeker, 1853, Nat. Tijds. Nederland Indie, 4: 253 (Sumatra)

Sciaena vogleri Gunther, 1860, Cat. Fish. Br. Mus., 2:294;— Day, 1876, Fishes of India, pt.2:186, pl.45, fig.1;— 1889, Fauna Br. India, 2:113.

Pseudosciaena vogleri Bleeker, 1874, Verh. kon Akad. Wet. Amsterdam, 14:35 (Sumatra);— 1877, Atlas Ichth. Ind. Neerland, 9, pl.(3): 386, fig.4.

Johnieops vogleri Mohan, 1972, Indian J. Fish., 16:82-98;— Fisher and White head, 1974, F.A.O. Sp. ident. Sheets Fish Purposes. 3 Sciaen. Johps 3.

Material:

2 specimens: Calcutta: 121 mm, 127 mm, males, 10-11-69. 3 specimens: Kakinada, 127 mm, male, 207 mm, male, 215 mm, male, 194 mm, female, 183 mm, female, 5-12-68. 6 specimens: Mandapam, 170 mm, male, 14-7-69; 160 mm, male, 3-2-70; 155 mm, male, 1-7-69; 182 mm, female, 19-10-71; 166 mm, female, 14-1-71; 163 mm, female, 27-4-71. 1 specimen: Puthanthurai (near Cape Comorin), 160 mm, female, 1[illegible]-6-71.

Description:

D.X, I, 26-31; P.16-18; A.II, 7; C.17, Ll.46-48; Ltr.7-8/1/10-12. G.R.5-6/1/9-13.

Body spindle shaped, head pointed, dorsal profile convex mouth terminal, cleft of mouth oblique; maxillary extends to middle of eye; snout not overlapping lower jaw; upper jaw with an outer row of enlarged teeth and an inner row of minute teeth; two pairs of teeth enlarged anteriorly (more than 2 times of other teeth) but not caninoid,; lower jaw with an outer row of villiform teeth and an inner row of well spaced distinct enlarged teeth; pharyngeal teeth well developed; preopercle serrated. Cycloid scales on cheeks, preopercles and opercles ctenoid scales on abdomen and caudal peduncle; lateral line scales with fiburcated tubules, scales extend to tip of caudal fin; gas bladder 'johnius type'; the first tubules swollen arborescent tubules 14; snout with three well developed rostral pores and five marginal pores; lower jaw with a distinct triangular outer mental pore, and slit-like inner mental pore on each side and a common median pore; otoliths 'Johnius type' broad anteriorly and tapering posteriorly with a well developed posterior groove.

First dorsal spine minute, third and fourth longest, spines not robust, membrane delicate, first dorsal fin deeply notched, second anal spine short and weak, about half of first anal ray; pectoral fin short, first rays of pelvics filiform; base of second dorsal and anal with 2-3 rows of minute scales; gill rakers short and dentate.

Opercle with a steel blue blotch, body grey dorsally ~~ax~~ and hyaline ventrally; two third of first dorsal fin grey, tip of second dorsal light grey; colour varies according to the habitat; branchial and body cavities black.

Detailed morphometric measurements and body proportions are given in the Table 9.

<u>General distribution</u>:

Calcutta, Kakinada, Mandapam, Puthanthurai (near Cape Comerin).

<u>Remarks</u>:

This species is closely related to <u>Johnieops sina</u> but for the pointed snout, well developed dentition and less number of gill rakers.

Johnieops osseus (Day)

(Plate III, Fig. 3a)

Sciaena osseus Day, 1876, Fishes of India, pt.2:193, pl.46, fig.3. (Type locality: Malabar coast);-- 1889, Fauna of Br. India, Fishes, 2:123.

Bola ossea Jordan and Stark, 1917, Ann. Carnegie Mus., 11: 453 (Ceylon).

Johnius osseus Munro, 1955, The Marine and fresh water fishes of Ceylon: 154;-- 1959, Misra, Rec. Indian Mus., 57: 270-271 (Compiled);-- Khalaf, 1961, Fishes of Iraq:94;-- Menon & Yazdani, 1963, Rec. Zool. Surv. India, 61:144.

Pak osseus Talwar, 1969, J. mar. biol. Ass. India, 11:324-328 (Malabar coast, type locality specimen).

Johnieops osseus Mohan, 1972, Indian J. Fish., 16:82-98.

Material:

5 specimens: Mandapam (Gulf of Mannar), 167 mm, female; 168 mm, male, 10-11-68; 149 mm, male, 17-9-68; 126 mm, male, 7-8-69; 150 mm, male, 10-10-70. 4 specimens: Pamban (Gulf of Mannar), 95 mm, male, 10-8-71; 132 mm, female, 14-1-69; 58 mm, male, 14-1-69; 176 mm, male, 9-7-70.
3 specimens: Kakinada, 139 mm, female, 10-8-68; 151 mm, female, 11-8-68; 143 mm, male, 11-8-68.
1 specimen: Calcutta, 157 mm, male, 10-11-68.
1 specimen: Neendakara, 134 mm, male, 7-9-69.

Description:

D.X, I, 25-30; P.17-18; C.17; A.II, 7.Ll.47-49; Ltr.5-7/1/10-13; G.R.5-6/1/11-14.

Body spindle shaped, head blunt, dorsal profile convex lower jaw shorter than upper jaw, cleft of mouth slightly oblique reaching posterior margin of orbit; snout slightly overlaps the upper jaw, eyes large; upper jaw with an enlarged outer row of teeth and an inner villiform row; lower jaw with an inner row of enlarged teeth and a band of villiform teeth; pharyngeal teeth well developed; preopercle serrated; scales cycloid on head and ctenoid on other parts of body; lateral line extends to caudal fin.

Gas bladder 'johnius type' with anterolateral expansions, 13-14 arborescent tubules; otoliths (sagitta) 'johnius' type; upper jaw with three rostral pores and five marginal pores; lower jaw with five mental pores; outer mental pores triangular, inner mental pore slit-like, median mental pore distinct; spines of first dorsal weak, dorsal fin deeply notched, last spine of first dorsal shorter than first spine of second dorsal; caudal fin rhomboid; second anal spine short, slightly longer than eye diameter; outer rays of pelvic fins filiform, pectoral fins long, more than three fourth of head; base of second dorsal and anal fins with a row of scales; gill rakers slender, short with minute, stunted spines on one side.

First dorsal black, opercle with a steel blue blotch, body pale grey dorsally and hyaline ventrally.

Detailed morphometric measurements and body proportion are given in the Table 10.

Distribution:

Malabar coast, Pamban (Gulf of Mannar), Kakinada, Calcutta.

Johnieops sina Cuvier
(Plate III, Fig.4a)

Corvina sina Cuvier, 1830, Hist. Nat. Poiss., 5:122, (type locality: Pondicherry, Malabar);-- Valenciennes, 1834, Voy. Ind. orient. Belanger, Zool., 359, (Malabar; Pondicherry);-- Richardson, 1846, Ichth. China Japan: 225 (China);-- Bleeker, 1853, Verh. Batav. Genootsch, (Japan) 25:12.

Sciaena sina Gunther, 1860, Cat. Fish. Br. Mus., 2:292;-- Day, 1865, Fish Malabar:52; 1876, Fishes of India pt.2: 186, pl.4, fig.2;-- 1889, Fauna of Br. India, 2: 114;-- Zugmayer, 1913, Abh. Bayer Akad. Wiss. math.-phys.KL., 26, pt.6:12 (Mekaran, Oman).

Johnius sina Blyth, 1860, J. Asiat. Soc. Bengal, 29:141 (Sittang River);-- Bleeker, 1874, Verh. Kon. Akad. Wet. Amsterdam, 14, no.4:54;-- Fowler, 1928, J. Bombay Nat. Hist. Soc., 33, no.1:115 (Bombay);-- Munro, 1955, Marine and Freshwater Fishes of Ceylon.

Johnius diacanthus (part) Fowler, 1926, J. Bombay nat. Hist. Soc., 30, no.4:9 (Lapsus).

Nak sina Talwar and Joglekar, 1969, J. Inland Fish. Soc. India, I:1-5.

Johnieops sina Mohan, 1972, Indian J. Fish., 16:87-95;--
Fischer & Whitehead, 1974, F.A.O. Sp. ident. Sheets Fish Purposes, 3: Sciaen. Johps.2.

Material:

1 specimen: Calcutta, 158 mm, female, 28-11-68.
1 specimen: Waltair, 218 mm, male, 13-12-68.
5 specimens: Madras, 23[illegible] mm, male, 263 mm, female (mature); 155 mm, female, 231 mm, male, 18-12-68; 264 mm, female, 7-11-68; (all from the off-shore). 2 specimens: Keelakarai, 185 mm, female (mature), 5-5-71; 150 mm, female, 15-5-71. 6 specimens: Mandapam (Palk Bay), 168 mm, female, 7-10-68; 150 mm, female, 193 mm female (mature), 10-7-69; 143 mm, female, 141 mm, female (mature, 171 mm, female (mature) 28-1-71.

Description:

D.X, I, 26-31; P.16-18; A.II, 7; C.16-17;
Ll.47-50; Ltr.5-8/1/10-12; G.R.5-7/1/10-15.

Body spindle shaped, head pointed, dorsal profile convex maxillary extending to posterior half of eye, cleft of mouth slightly oblique, mouth terminal (subterminal in large specimens); snout not overhanging the upper jaw, eyes above the cleft of mouth; upper jaw with an outer row of enlarged teeth and an inner row of villiform teeth; lower jaw with an inner row of distinctly enlarged teeth and an outer row of minute teeth, anterior upper jaw teeth larger; canines absent; pharyngeal teeth well developed; preopercle serrated.

Snout with three rostral pores; and five marginal pores; outer marginal pores deep, inner and median marginal pores shallow; lower jaw with six mental pores; outer mental pores large, inner mental pores slit-like and the median pores small and open very close to each other; gas bladder (johnius type) with 15-16 arborescent tubules; sagitta 'johnius type'; lateral line originates above the opercle, terminating at caudal tip; lateral line scales with branched tubules; cycloid scales on cheeks, opercles, preopercles and ctenoid scales on body; first dorsal spine very short, third and fourth spines longest, spines not robust, membrane delicate; base of second dorsal with a row of scales; dorsal fin notched deeply caudal fin cuneate; anal spine short and weak first rays of pelvic fins filiform; gill rakers short, pointed with 2-3 rows of simple spines (gill rakers stumpy in large specimens).

Detailed morphometric measurements and proportion are given in the Table 11).

Upper two thirds of first dorsal fin dark grey, tip of second dorsal grey, other fins hyaline. Opercle with a steel blue blotch, body dorsally slightly grey, ventrally hyaline. Colour varies from light grey to grey.

Distribution:

East Africa, South Africa, Mekaran, Oman, India, East Indies, Philippines, China, Japan.

Remarks:

This species is widely distributed in Indo-Pacific and it shows considerable local variations.

Johnieops dussumieri (Cuvier)

Corvina dussumieri Cuvier,1839, Regne animal, pl.28, Fig.2.

Sciaena parva Gilchrist and Thompson, 1911, Ann. S. Afr. Mus., 6: 183 (Estuary of Tugela, S. Africa River).

Sciaena parvus Fowler, 1925, Proc. Acad. Sci. Philad:247 (Natal).

Nak menoni Twalwar and Joglekar, 1969, J. Inland Fish. Soc. India, I: 1-5, fig.1.

Material

8 specimens: Ernakulam, 144 mm (T.L.), female, 10-9-69; 155 mm, male, 10-9-69; 145 mm, male, 10-9-69; 138 mm, female, 10-9-69; 142 mm, female, 10-9-69; 136 mm, female, 10-9-69; 135 mm, male, 10-9-69; 133 mm, male, 10-9-69.

Description:

D.X, I, 25-29; P.16-18; A.11, 7; Ll.47-49; Ltr.5-7/1/10-12; G.R.5-7/1/14-16.

Body spindle shaped, dorsal profile convex, head pointed, interorbital space flat, snout slightly swollen, lower jaw shorter than upper; maxillary extending to posterior end of eye; cleft of mouth slightly oblique, mouth subterminal, snout not overhanging upper jaw, but slightly projects in front of it. Eyes small, outer row teeth of upper jaw slightly enlarged, inner rows villiform; lower jaw with an inner row of enlarged teeth and outer rows of villiform teeth, pharyngeal teeth well developed, preopercle not serrated.

Gas bladder 'johnius type' with 14 arborescent tubules, otoliths (sagitta) 'johnius type'; lateral line originates above opercle and terminates at tip of caudal fin; lateral line scales with tubules; upper jaw with three rostral pores, and five marginal pores; outer marginal pores well developed, lower jaw with six pores; cycloid scales on cheeks, preopercle and opercle and ctenoid scales on body; membranes of first dorsal delicate, spines not strong, second anal spine weak, about one fourth of head length; caudal cuneate, first rays of pelvic fins filiform; base of second dorsal and anal fins with a rows of scales; gill rakers short, with a row of simple spines on one side.

(Detailed morphometric measurements and proportions are given in the Table 12.)

First dorsal black, upper margin of second grey; body light grey dorsally and hyaline ventrally, opercle with a steel blue blotch.

<u>Distribution:</u>

East coast of Africa, coasts of India.

Remarks:

This species resembles *Johnsops sina* in many characters But it differs from it in having feeble dentition, cleft of mouth being more horizontal and the gill rakers being longer. Recently Talwar and Joglekar (1969) described *Wak memoni* from Calcutta. But when the morphometric characters of this species are statistically analysed it does not seem to be distinct from *J. dussumieri* Cuvier.

Johnieops macrorhynus Mohan

(Plate IV, Fig.1a)

Johnieops macrorhynus Mohan, 1975, *Matsya*, 1:19-25 (Type locality: Mandapam Camp).

Material

4 specimens: Veraval, 179 mm (T.L.), male, 195 mm, female (ripe); 188 mm, female (ripe); 175 mm, male, 3-11-73. 4 specimens: Bombay, 162 mm, female, 29-10-72; 168 mm, female, 29-10-72; 190 mm, male, 12-11-72; 206 mm, female, 3-4-72. 1 specimen: Versova (Bombay), 155 mm, male, 29-10-72. 6 specimens: Mandapam, 134 mm, male, 10-8-69; 203 mm, female (ripe) 14-10-69; 170 mm, male, 7-10-68; 206 mm, male, 12-8-69; 167 mm, male, 24-1-68; 184 mm, male, 10-11-70. 1 specimen: Waltair, 195 mm, male, 3-12-68. 4 specimens: Calcutta, 133 mm, male, 15-11-68, 122 mm, male, 15-11-68; 157 mm, female (ripe), 15-11-68; 142 mm, female, 16-11-68.

Description

D.X, 1,26-30; P.16-17; C.17; A.11, 7; Ll.46-49;
Ltr.5-7/1/10-12; G.R.3-5/1/5-8.

Body spindle shaped, dorsal profile convex, lower jaw shorter than upper jaw, mouth inferior, cleft of mouth horizontal, extending to three fourth of eye; eyes large, equals to snout; upper jaw with an outer row of enlarged teeth and an inner row of villiform teeth; lower jaw with outer rows of villiform teeth and an inner row of enlarged teeth, (enlarged teeth are molar like in large specimens); pharyngeal teeth well developed; preopercle serrated; lateral line pores well developed; upper jaw with three rostral pores and five marginal pores, lower jaw with five mental pores; Gas bladder 'johinus type' with 13-14 pairs of lateral arborescent tubules; sagitta 'Johinus type'; preopercle, opercle and body with ctenoid scales, anterior part of cheeks with cycloid scales; dorsal spine weak, first spine minute, second spine as long as third; first spine of second dorsal longer than last spine of first dorsal; caudal fin cuneate; second anal spine short weak and less than half of first anal ray; first ray of ventral fins filiform; base of second dorsal and anal fins with rows of minutes scales; gill rakers short, stumpy with minute spines on each side.

Detailed morphometric measurements and body proportions are given in the Table 13.

When fresh golden tinge ventrally and pale brown dorsally. Preserved specimens grey dorsally and white ventrally; a steel blue blotch on opercle; two thirds of first dorsal fin dark grey, second dorsal light grey. Colour varies from golden yellow to pale grey.

Distribution:

East and West coasts of India and Ceylon.

Remarks:

Johnieops macrohynus is very close to *Johnius elongatus* but for the dentition and the barbels. It may be due to the similar ecological nich both the species occupy. *J. macrorhynus* shares some of the characters like inferior mouth and well developed sensory pores which are characteristic of the species of the genus *Johnius*.

Subfamily : Kathalinae

Gas bladder with one pair of anterior tubules; antero-lateral expansion absent; mental pores five; sagitta with a posterior depression; teeth not differentiated in lower jaw, mental barbels absent.

Kathala Mohan

Kathala Mohan, 1969, *Curr. Sci.*, *38*:295-296;-- 1972, *Indian J. Fish.*, *16*:82-98.

Dhoma, Talwar and Joglekar, 1970, *J. mar. biol. Ass. India*, *10*:361-365 (1968).

Diagnosis:

Gas bladder simple, round anteriorly, tapering posteriorly with a pair of short tubules on each side; lateral arborescent tubules absent; snout with 3 rostral pores and five marginal poers ~~and five marginal pores~~; lower jaw with one median pore an inner and an outer mental pore on each side; otolith (sagitta) pointed anteriorly with a shallow anterior depression and truncated posteriorly with a deep posterior groove; teeth not differentiated in lower jaw; gill rakers long,slender and dentate; mouth terminal, oblique, upper jaw not overlapping lower. D. IX-X, I, 26-29.

Type:

Corvina axillaris Cuvier, 1830.

Remarks:

This genus is mono-typic.

Kathala axillaris (Cuvier)

(Plate IV, Fig.2a)

Corvina axillaris Cuvier, 1830, Hist. Nat. Poiss., 5:113, 'Typelocality': Malabar);— Valenciennes, 1834, Voy. Ind. Orient. Belanger, Zool., 356, (Malabar coast);— Gunther, 1860, Cat. Fish. Br. Mus., 2:302;— Day, 1865, Fishes of Malabar:53.

Sciaena axillaris Day, 1876, Fishes of India, pt.2:188, pl.43, fig.6, (Orissa, Madras);— 1889, Fauna Br. India Fish., 2:116.

Bola axillaris Jordan and Starks, 1917, Ann. carnegie Mus., 11:45, (Ceylon).

Johnius axillaris Fowler, 1933, Bull. U.S. Nat. Mus., No.100 12: 397, (Luzon);-- Munro, 1955, Marine and fresh water fishes of Ceylon: 55;-- Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65:335-347 (Waltair).

Paeduosciaena axillaris Herre, 1934, Note Fish. Zool. Mus. standford Univ:57;-- Weber and de Beaufort, 1936, Fishes Indo-Aust. Archipel.7:511-512;-- Misra, 1959 Rec. Indian Mus., 59:297;-- Munro, 1967, Fishes of New Guinea:344.

Wak axillaris Chu, Lo and Wu, 1963, Monogr. Fish. China, Publ. Shanghai Fish. Inst., 33-34.

Dhoma axillaris Talwar and Joglekar, 1970, J. Mar. biol. Ass. India, 10:361-365 (1968). (Orissa, Calicut, Madras).

Kathala axillaris Mohan, 1969, Curr. Sci., 38:295-296;-- 1972, Indian J. Fish., 16:82-96;-- Fischer & Whitehead 1974, F.A.O. Sp. ident. Sheet Fish Purposes 3: Sciaen. Kath.1.

Material:

1 specimen: Colachel, 152 mm (T.L.), male, 17-4-69. 5 specimens: 145 mm, female; 125 mm, male, 119 mm, female; 120 mm, male, 120 mm, male; all from Calicut collected on 10-8-69 (Trawl net). 2 specimens: Kakinada, 154 mm, female, 121 mm, male, 5-12-69. 3 specimens: Vizhinjam, 154 mm, female, 146 mm, male; 149 mm, male, 14-4-68. 1 specimen:

Madras, 106 mm, male, 12-11-68. 1 specimen: Neendakarai, 145 mm, male, 12-8-68.

Description:

D.X, I, 26-29; P.16-17; A.11, 7; C.17, Ll.46-50; Ltr.8-10/1/11-12; G.R.9-11/1/19-22.

Dorsal profile convex; cleft of mouth oblique extending beyond middle of eyes, teeth villiform on both jaws, pharyngeal teeth well developed preopercle serrated; lateral line scales with a central pore and bifurcated tubules; cheeks, opercle and nape with cycloid scales and body with ctenoid scales; dorsal spines strong, third and fourth spines longest first dorsal continuous with second dorsal; base of second dorsal and anal fins with minute scales; second anal spine s strong, 1.5 times longer than eye; first rays of pelvic fins filiform; gill rakers slender, long, dentate and about half of eye.

Dorsal surface grey, a characteristic large dark grey blotch in axilla, another blue blotch on opercle, upper part of first dorsal with a kark grey blotch, other fins with grey pigmentation.

Detailed morphometric measurements and body proportions are given in the Table 14.

Distribution:

India (Karwar, Mangalore, Calicut, Neendakara, Vizhinjam, Keelakarai, Pamban, Madras, Kakinada, Waltair); Ceylon, Indo-China; Southern China, Java, New Guinea.

Subfamily : Otolithoidinae

Gas bladder with one or two pairs of tubules; anterior lateral expansion of the gas bladder absent; sagitta elongate with shallow anterior; mental barbels absent.

Tribe: Macrospinosini.

Gas bladder with two pairs of short tubules on each side; lower jaw with 5 mental pores.

Macrospinosa Mohan

Macrospinosa Mohan, 1969, *Curr. Sci.* 38:295-296;— 1972, *Indian J. Fish.*, 16:82-98.

Diagnosis:

Gas bladder simple, round in front with a pair of short bifurcated tubules on each side, otolith elongated with a distinct anterior depression and marginal groove; snout with 3 distinct rostral and five marginal pores; lower jaw with six mental pores; teeth enlarged on upper and lower jaws; mouth subterminal; second anal spine stout, equals postorbital length.

Type:

Bola cuia Hamilton

Remarks:

This genus is monotypic.

Macrospinosa cuia (Hamilton)

(Plate IV, Fig.3a)

Bola cuia Hamilton, 1822, Fishes of Ganges: 81, 369, fig.27 (Type locality: Ganges estuary)

Corvina cuia Cuvier, 1830, Hist. Nat. Poiss., 5:96;— Blyth, 1860, J. Asiat. Soc. Bengal, 29:141; (Sittang River);— Gunther, 1860, Cat. Fish. Br. Mus., 2:300 (Calcutta).

Sciaenoides asper Blyth, 1860, J. Asiat. Soc. Bengal, 29:140 (Sittang river).

Sciaena cuia Day, 1878, Fishes of India, pt.2; 187, (Estuaries of Ganges);— 1889, Fauna Br. India, 2:115.

Johnius cuius Fowler (in part), 1933, Bull. U.S. Nat. Mus., (100), 12:390 (India).

Nak cuia Lin, 1938, Ling. Sci. J., 17, no.3:379, (Yankiang, Kwangtung);— Chu, Lo and Wu, 1963, Monogr. Fish. China, Shanghai Fish. Institute, 1-100.

Macrospinosa cuia Mohan, 1969, Curr. Sci., 38:295-296, (Ganges estuary);— 1972, Indian J. Fish., 16:82-96 (Calcutta);— Fischer & Whitehead, 1974, F.A.O. Sp. ident. Sheet Fish Purposes, 3: Sciaen:6.

Material:

4 specimens: 291 mm (T.L.), male, 28-11-69; 190 mm, female, 22-11-69; 203 mm, male, 20-11-69; 190 mm, female, 21-10-69; all from Calcutta.

Description:

D.X, I, 28-29; A.11, 7; P.17; Ll.48-50; Ltr.8-10/1/11-12; G.R.3-4/1/8-9.

Dorsal profile convex, head pointed, interorbital space flat, mouth oblique, upper jaw shorter than lower, cleft of mouth extending beyond half of orbit; eyes large, upper jaw with an outer row of enlarged teeth, and inner rows of villiform teeth, lower jaw with an inner row of enlarged teeth and outer rows of villiform teeth, pharyngeal teeth, well developed, snout with three rostral and five marginal pores on upper jaw and six mental pores on lower jaw; outer mental pores distinct; scales feebly ctenoid on cheeks, preopercle, opercle, interorbital and nape, strongly ctenoid on body; lateral line scales with central pores; gas bladder rounded anteriorly with two pairs of minute anterior tubules; lateral line extends to tip of caudal fin; dorsal spines strong, stout; first dorsal spine distinct, dorsal fin shallowly notched; caudal fin cuneate; first anal spine robust, about 2/3 of eye; second anal spine strong, equals postorbital length; gill rakers pointed, about half of eye and dentate on one side.

Body dorsally with ten oblique rows of narrow black bands and five grey bands between lateral line and anal base, first and second dorsal with 2-3 dark narrow bands, opercle with a steel blue blotch.

Detailed Morphometric measurements and body proportion are given in the Table 15.

<u>Distribution</u>:

Estuaries of Ganges; Sittang River; Yankiang and Kwangting (China); Indo-China.

<u>Remarks</u>:

Talwar (1970) created a new genus <u>Cantor</u> to accommodate this species, but the gas bladder he described does not appear to belong to this species. Fowler (1933) synonymised this species with <u>Pseudotolithus</u> <u>mitsukurii</u> (Jordan & Snyder) which is a valid species and is not sofar reported from India.

Tribe : Otolithoidini

Gas bladder with two pairs of tubules on each side. It may originate from the anterior end of the bladder as in Panna or from posterior ends as seen in <u>Otolithoides</u>.

<u>Otolithoides</u> Fowler

<u>Sciaenoides</u> (Not Richardson, 1843) Blyth, 1860, <u>J</u>. <u>Asiat</u>. <u>Soc</u>. <u>Bengal</u>, <u>29</u>: 139;-- Day, 1878, <u>Sea Fish</u>. <u>India</u>:193.

Otolithoides Fowler, 1933, *U.S. Nat. Mus. Bull.*, 100, *12*: 361. (Genotype: *Otolithus biauritus* Cantor, 1849 (1850); Weber and Beaufort, 1936, *Fish. Indo-Austr. Archepel.*, *7*:499; Chu, Lo and Wu, 1963, *Monograph of Fishes of China*:36-37; Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Diagnosis:

Gas bladder simple, without lateral arborescent tubules; a pair of tubules originate from the posterior end of gas bladder extending to base of cranium along the lateral sides of the bladder remifying at its tip; sagitta elongated with a distinct anterior depression and indistinct posterior groove; snout with three rostral pores and five marginal pores; lower jaw with 3 mental pores; teeth differentiated in both jaws, upper jaw with one or two canines on each side. D.IX-X, I, 28-44.

Type:

Otolithes biauritus Cantor.

General distribution:

India, Burma, Malay peninsula, West Indies.

Remarks:

This genus is represented by two species from India.

Otolithoides biauritus (Cantor)

(Plate IV, Fig.4a)

Otolithus biauritus Cantor, 1850, *Cat. Malayan Fish*:57 (Sea of Pinang to Tenasserim);-- 1852, Bleeker, *Nat. Tijdschr. Ned. Indie*, *3*(1851) 56;

Collichthys biauritus Gunther, 1860, *Cat. Fish. Br. Mus.*, *2*:315 (Sea of Pinang to Calcutta);— 1874, *Verh. Akad. Amsterdam*, *14*(1873):15 (Pinang, Singapore and Borneo).

Collichthys biaurita Dunker, 1904, *Mitt. Naturh. Mus. Hamburg*, *21*:1(1903) (Jeram).

Sciaeniodes biauritus Blyth, 1861, *J. Asiat. Soc. Bengal* (1860):139 (Sittang River);— Bleeker, 1877, *Atlas Ichth. Ind. Neerland.*, *9*:386, fig.3;— Day, 1878, *Fishes of India*, pt.2:194, pl.47, fig.1;— Tirant, 1929, *Service Oceanogr. Pech. Indo-Chine, note 6*: 169;— Hardenberg, 1931, *Treubia*, 13(1):133. (Rokan mouth, Sumatra).

Sciaena biauritus Seale, 1914, *Philippine J. Sci.*, *9*(1):69. (Hong Kong).

Otolithoides biauritus Fowler, 1933, *Bull. U.S. Nat. Mus.* *12*:365;— Hardenberg, 1934, *Treubia*, *14*:309;— Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archipel.*, *7*:500;— Chu, Lo and Wu, 1963, *Monograph of Fishes of China*:39;— Mohan, 1972, *Indian J. Fish.*, *16*:82-95 (Bombay, Mandapam, Calcutta);— 1973, *J. mar. biol. Ass. India*, *14*:415-417. Fischer & Whitehead, 1974, F.A.O. Sp. ident sheet. Fish Purposes, 3:Sciaen. Otol.

Otolithus brunneus Day, 1873, *J. Linn. Soc. London*, *11*:524 (Bombay).

Sciaenoides brunneus Day, 1878, Fishes of India:195;-- Fish. Brit. India, 2:126;-- Hardenberg, 1931, Treubia, 13(1):134 (Sumatra).

Collichthys brunneus Fowler, 1928, J. Bombay Nat. Hist. Soc., 33:115 (Bombay).

Otolithoides bruneus Fowler, 1933, Bull. U.S. Nat. Mus., 100, 12:366 (Nanking, Shanghai and Bombay);-- Fowler, 1934, Proc. Acad. Nat. Philadelphia, 86:153 (Bombay);-- Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel., 7:503;-- Chu, Lo and Wu, 1963, Monograph of Fishes of China:38;-- Menon and Yazdani, 1968, Rec. Zool. Sur. India, 61, pt.2:144 (Bombay).

Material:

2 specimens: Bombay, 367 mm, male, trawl net; 296 mm, male, trawl net, 5-1-70;
2 specimens: Calcutta, 240 mm, female, trawl net; 305 mm, male, trawl net, 28-11-71;
1 specimen: Mandapam, (Palk Bay), 540 mm, male, trawl net, 8-7-67 (CMFRI S.No.775, F/89/539).

Description:

D.IX, I, 28-29; P.16-18; A.II, 7; C.16-17; Ll.61-64; Ltr.18-20/1/19-20. G.R.5/1/10-11.

Body elongated; head pointed, interorbital space broad, mouth subterminal, cleft of mouth slightly oblique extending beyond orbit; eyes small; lower jaw with an outer row of minute teeth and an inner row of enlarged teeth, upper jaw with an outer row of enlarged teeth and an inner row of minute teeth, anterolaterally one or two upper jaw teeth enlarged on each side; pharyngeal teeth well developed; rostral and marginal pores in distinct; snout margin faintly cremulated; lower jaw with 2 median mental pores and an inner mental pore on each side; a tubule originates from the posterior end of each side of gas bladder extending to base of ear ossicles.

First dorsal spine weak, second dorsal spine shorter than third, membrane thick, dorsal fin deeply incised; 2-3 rows of minute scales on the base of econd dorsal; caudal fin cuneate; second anal spine weak first spine of pelvic fins weak, first ray not elongated; cycloid scales on cheeks, interorbital, preopercle, nape and base of dorsal fins; ctenoid scales on abdomen and caudal peduncle; scales on interorbital and post orbital regions enlarged; gill rakers well developed, flat, pointed, with minute spines on inner side.

Colour varies from hyaline to dark grey; pectoral, caudal and anal fins grey, first dorsal with a grey tint; lateral line with a white streak, a grey blotch on opercle, abdomen grey.

Detailed morphometric measurements and body proportions are given in the Table 16.

Distribution:

Gulf of Cutch, coast of Gujarat and Maharashtra, east coast of India, Ganges estuary, Sitang river, Sea of Penang, Singapore, Sumatra, Indo-China, Borneo, Luzon, Hong Kong, South China.

Remarks:

Otolithoides brunneus (Day, 1873), is a junior synonyme of *O. biauritus* Cantor, 1850 (Mohan, 1973).

Otolithoides pama (Hamilton)

(Plate V, Fig.1a)

Bola pama Hamilton-Buchanan, 1822, *Fishes of Ganges*:79, 368, pl.32, fig.26, (Calcutta).

Sciaena pama, Cuvier, 1830, *Hist. Nat. Poiss.*, *5*:55, pl.101 (Bengal & Irawaddi River);— Bleeker, 1855, *Verh. Batav. Gen.*, *25*:92.

Collichthys pama Gunther, 1860, *Cat. Br. Mus.*, *2*:316 (Calcutta, Bay of Bengal);— Fowler, 1930, *Proc. Acad. Nat. Sci. Philadelphia* (1929):650 (East Indies);— 1932, (1931): 446, (West coast of Malaya).

Sciaenoides pama Blyth, 1960, *Proc. Asiat. Soc. Bengal*, *29*: 139 (Sitang River);— Day, 1878, *Fishes of India*,pt.*2*: 193 (Calcutta);— 1889, *Fauna Br. India*, *2*:124;— Lloyd, 1907, *Rec. Indian Mus.*, *1*:226;— Hardenberg, 1931, *Treubia*, *13*:133 (Sumatra).

Pama pama Fowler, 1933, Bull. U.S. Natn. Mus., no.100, 12: 360. (East Indies; Bagan Datah, West coast of Malaya);-- Hardenberg, 1934, Treubia, 14:309;-- Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel., 7:496 (Sumatra).

Otolithoides pama Mohan, 1972, Indian J. Fish., 16:82-95 (Calcutta). Fischer and Whitehead, 1974, F.A.O. Sp. ident. Sheets. Fish Purposes, 3: Sciaen. Otold. 2.

Material:

10 specimens: Calcutta, 207 mm (T.L.), female, 200 mm, male, 176 mm, female; 185 mm, male; 210 mm, male; 213 mm, female; 170 mm, female; 115 mm, 127 mm, 115 mm, juveniles, 10-11-69.

Description:

D.IX-X, I, 40-44, P.16-17; A.II, 7-8; C.17; Ltr.15/1/16-20; Ll.46-51; G.R.5-7/1/10-13.

Body elongated, head pointed, dorsal profile ascends gradually, snout not overlapping the lower jaw, free margin of snout not crenulated, maxillary extending beyond orbit, cleft of mouth slightly oblique; eyes small, interorbital space broad, lower jaw with an outer row of minute teeth and an inner row of enlarged teeth, upper jaw with an inner row of minute teeth and an outer row of enlarged teeth, two or three upper jaw teeth caninoid anterolaterally, tip of premaxillary with a cluster of minute teeth, pharyngeal teeth well developed, preopercle serrated.

Rostral and marginal pores of upper jaw not distinct; lower jaw with two distinct median mental pores and an inner mental pore on each side; from each side of the posterior end of gas bladder a tubule orginates extending on each side of the body cavity anteriorly and ramifing below ear ossicles, otolith (sagitta) elongated with a shallow anterior and posterior depression; lateral line extending anteriorly to orbit as a closed tube; lateral line scales large with a central pore and reticulating closed tubes.

Cycloid scales on cheeks, interorbital, preopercle and opercle; ctenoid scales on base on first and second dorsal, belly and caudal peduncle; scales minute and arranged in oblique rows; dorsal spines weak, membrane delicate, first spine minute, second shorter than third, third and fourth spines longest, first spine of second dorsal weak, rays longer posteriorly; caudal fin cuneate, median rays elongate; second anal spine weak and short originating below 22nd dorsal ray; axillary scales absent; pelvic fins with a short spine, first ray longest; gill rakers long and flat with pointed simple spines on one side.

Body hyaline or pale brown, tip of first dorsal grey, opercle with a grey blotch.

Detailed morphometric measurements and body proportions are given in the Table 17.

<u>Distribution:</u>

Calcutta, Coast of Burma, East Indies.

Remarks:

As the gas bladder, otolith and lateral line sensory pores of this species agree with those of the genus *Otolithoides* Fowler, this species is included in this genus.

Panna Mohan

Panna Mohan, 1969, *Curr. Sci.*, *38*:295-296;-- 1972, *Indian J. Fish.*, *16*:82-98.

Diagnosis:

Body elongated, gas bladder simple with an anterior tubule on each side dividing into anterior and posterior tubules, anterior tubules ramify below ear ossicles and the posterior tubule extend to the hind end of the bladder; otolith (sagitta) narrow, elongated, the anterior end with a shallow depression and the posterior end with a deep curved groove ventrally; snout ~~xxx~~ with three indistinct rostral pores and five marginal pores; lower jaw with six mental pores - 2 median, an inner and an outer poreson each side, teeth enlarged in both jaws, upper jaw with two pairs of caninoid teeth anteriorly; second anal spine and dorsal spines weak. D.VII-IX, 1, 31-35.

Type species:

Otolithus microdon Bleeker, 1849.

Distribution:

India, East Indies, Indo-China, China.

Remarks:

This genus is represented by one species in India.

Panna microdon (Bleeker)

(Plate V, Fig. 2a)

Otolithus microdon Bleeker, 1849, *Verh. Bat. Gen.* XXII, *Ichth. Madura*:10 (1848).

Sciaena microdon Gunther, 1860, *Cat. Fish. Br. Mus.*, 1:2;— Dunker, 1903, *Mitt. Naturh. Mus. Hamburg*. 21:154 (1904) (Singapore);— Lloyd, 1907, *Rec. Indian Mus.*, 1:226 (Akyab).

Collichthys microdon Bleeker, 1872, *Ned. Tijdschr. Dierk.*, 4: 142 (1871). (China).

Sciaenoides microdon Day, 1878, *Fishes of India*: 194, pl.45, fig.2 (Bombay, Orissa);— 1889, *Fauna Br. India*, 2:125;— Triant, 1929, *Ser. Oceanogr. Pech. Indo-China*, note 6:169 (Phuoc Hai Cochin China)

Otolithoides microdon Fowler, 1933, *Bull. U.S. Nat. Mus.*, no.100, 12:364-366;— 1934, *Proc. Acad. Nat. Sci. Philadelphia*, 84:153;— Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archipel.*, 7:503-504;— Chu, Lo and Wu, 1963, *Monogr. fish. China*:37.

Panna microdon Mohan, 1969, *Curr. Sci.*, 38:295-296.(Calcutta, Pamban);— 1972, *Indian J. Fish.*, 16:82-98;— Fisher & Whitehead, 1974, F.A.O. Sp. ident Sheet. Fish Purpose, 3: Sciaen. Pan.1.

Material:

5 specimens: Calcutta, 181 mm (T.L.), male, trawl net; 149 mm, female, 133 mm, male; 131 mm, male; 120 mm, male; 18-11-68; 1 specimen: Pamban (Palk Bay), 198 mm, female, gill net, 20-3-68; 1 specimen: Panaikulam (Palk Bay), 215 mm, female, gill net, 24-2-67.

Description:

D.VII-IX, I, 31-35; P.18-20; C.17; A.II, 7-8;
Ll.48-49; Ltr.12-15/1/13-16; G.R. 5-6/1/10-12.

Body elongated, head pointed, snout not overhanging; cleft of mouth slightly oblique extending to posterior end of orbits, margin of snout feebly crenulated; rostral pores three, marginal pores five, not distinct; lower jaw with six distinct mental pores; eyes small; about one sixty in head; lower jaw with an outer row of villiform teeth and an enlarged inner row; upper jaw with an inner row of villiform teeth and an outer row of enlarged teeth, one or two canine teeth on each side; pharyngeal teeth not well developed; preopercle serrated; scales small, arranged in oblique rows; cycloid scales on cheeks, opercle and interorbitals and ctenoid scales on nape and body; third and fourth dorsal spine longest, spines weak, dorsal fin notched; caudal fin cuneate, anal fin originates below 15th ray of second dorsal, pectoral fins long, broad, axillary scales absent. Bases of anal and second dorsal with minute scales; gas bladder simple, with a tubule on each side which divide into anterior and posterior branches; otolith (sagitta) narrow and elongated with an anterior shallow depression and a deep curved groove posteriorly; gill rakers long, narrow and pointed with minute spines on inner side.

Greyish above, silvery below, opercle with a blush spot above; paired fins yellow, median fins dusky, two third of spines dorsal blackish.

Detailed morphometric measurements and body proportion are given in the Table 18.

Distribution:

Singapore, Penang; Sumatra, Strait of Madura; Java; Borneo, India (Bombay, Pamban, Panaikulam (Palk Bay), Calcutta), Indo-China and southørn China.

Bahaba Herre

Bahaba Herre, 1935, *Ling. Sci. J.*, 14, no.4:609;-- Chu, Lo & Wu, 1963, *Monogr. fish. China*:40;-- Trewavas and Talwar, 1972, *J. Fish. Biol.*, 4:11-16.

Diagnosis:

Gas bladder rounded anteriorly and tapering posteriorly, with a pair of unbranched tubules originating anteriorly extending to half of body; sagitta oblong with an distrinct anterior depression and curved posterior groove; rostral pores absent, marginal pores five, mental pores five; teeth differentiated in both jaws, caniniform teeth absent. D.X, 1, 24-26.

Type:

Nibea flavolabiata Lin.

Distribution:

Bombay and Sittang River.

Remarks:

This genus is represented by one species from India (Ganges estuary).

Bahaba chaptis (Hamilton)

Bola chaptis Hamilton, 1822, *Fishes of Ganges*:77 pl.10, fig.25 (Ganges).

Corvina chaptis Cuvier, 1930, *Hist. Nat. Poiss.*, *5*:130 (After Hamilton).

Sciaena diacanthus (part, not Lacepede) Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archepel*, *7*:515.

Nibea diacanthus (part, not Lecepede) Lin, 1938, *Ling. Sci. J.*, *17*: 161-173, 539-550.

Bahaba chaptis Trewavas & Talwar, 1972, *J. Fish. Biol.*, *4*:11;-- Talwar, 1972, *J. Fish. Biol.*, *4*:171-172.

Bahaba chaptis Talwar & Datta, 1972, *J. Fish. Biol.*, *4*:171-172.

Description:

D.X, I, 24-25; A.II. 7; Ll.51-52; Ltr.9-10/1/20; G.R.4-5/1/7-8.

In standard length, height of body 28.8-31.0; head 30.0-31.5. In head length eye 22.0-23.5, snout 20.0-21.0, interorbital space 13.7-14.3, upper jaw 40.0-44.0, lower jaw 52.0-53.3, pectoral fin 59.7-63.0, second spine 45.7-50.0 (all measurements in percentages).

Dorsal profile convex, mouth terminal, cleft of mouth oblique. Rostral pores absent, marginal pores five, lower jaw with a median pore and an inner mental pore on each side; eyes large, above the level of tip of mouth; upper jaw with an outer row of enlarged teeth and an inner band of villiform teeth; lower jaw with ~~xxxx~~ an outer row of minute teeth and an inner row of enlarged teeth, caniniform teeth absent; scales ctenoid except on snout and behind eye; lateral line scales with branched tubules; base of dorsal and anal fins with rows of scales, gas bladder with an anterior unbranched tubule extending backwards; sagitta with an enlarged anterior depression and curved posterior groove; dorsal spines robust, second anal spine strong about half of length of head; body slightly darker dorsally and first dorsal black distally, ~~xxx~~ second dorsal and caudal with narrow black streaks; pectoral, pelvic and anal fins colourless.

Morphometric measurements and meristic counts are given in the Table 19.

Distribution:

Sittang river, Ganges estuary and Bombay.

Subfamily : Sciaeninae

Gas bladder without arborescent tubules lower jaw with five mentel pores; inner mentel pore at the tip of the barbel; lower jaw teeth not differentiated.

Umbrina Cuvier

Umbrina Cuvier, 1817, *Regne Animal*, 2:297.

Diagnosis:

Gas bladder simple without arborescent tubules, teeth uniformly villiform in lower jaw; snout with 3 rostral pores and five marginal pores; lower jaw with five mental pores; median pore at the tip of a mental barbel. D.X, I. 27-29.

Type:

Sciaena cirrosa Linnaeus.

Distribution:

West coast of India, Coast of Arabia, East coast of Africa.

Remarks:

This genus is represented by one species from India.

Umbrina sinuata Day

Umbrina sinuata Day, 1876, *Fishes of India* pt.2: 182, pl.46, fig.1 (Type locality, Karachi);-- 1889, *Fauna Brit. India, Fishes, 2*:109, Fig.48. (Karachi, Muscat);-- Gilchrist and Thompson, 1908-1911, *Ann. S. Afr. Mus.*, *6*:182;-- Barnard, 1927, *Ann. S. Afr. Mus.*, 21, pt.2: 579 (Natal);-- Trewavas, 1964, *Copeia*: 107-117.

Umbrina striata Boulenger, 1887, *Proc. Zool. Soc. London*:660 (Type locality: Muscat);-- 1889-245 (Muscat);-- Gilchrist and Thompson 1908-1911, *Ann. S. Afr. Mus.*, *6*:181;--Zugmayer, 1913, *Abh. Bayer. Akad. Wiss., math.-phys. Kl.*, *26*:12. (Oman);-- Barnard, 1927, *Ann. S. Afr. Mus.*, *21*, pt.2:580.

Sciaena striata Fowler, 1925, *Proc. Acad. Sci. Philad*: 248 (Natal).

Umbrina sinuata Fisher & Whitehead, 1974, F.A.O. Sp. ident. Sheet Fish Purposes, 3: Sciaen.

Description:

D.X, I, 27-29; P.17, A.II, 7; Ll.44-50; Ltr.7/12.

Height of body 3.7 in total length; eyes 3.3 in head. Snout obtuse, swollen, overlapping the jaws, maxilla reaching middle of eye; preopercle serrated; rostral pores three, marginal pores five; lower jaw with an outer and an inner mental pore on each side; median pore at tip of mental barbel which is one fourth of eye; upper jaw with outer row of enlarged teeth, inner rows of villiform teeth; lower jaw with villiform teeth; dorsal spines weak, third spine longest; second anal spine strong, about 1/2 of head; caudal wedge shaped ctenoid scales on head and body, cycloid scales on snout and intraorbital region, anal and second dorsal base with a dense band of scales; lateral line scales with branched tubules; gas bladder simple, without arborescent tubules.

Body with nine sinuous brown bands, a dark blotch at axilla, first dorsal black, soft dorsal and anal fins with a black band, ventral fins black, caudal fin with a black tip and white outer margin.

Distribution:

Mekaran coast, Oman, East coast of Africa.

Pterotolithus Fowler

Pterotolithus Fowler, 1933, U.S. natn. Mus. Bull. 100, 12:359.

Diagnosis:

Body elongated, scales small; mouth terminal, jaws prominent; upper and lower jaws with well developed caninies; gas bladder round anteriorly with out antero-lateral expansions and tapering posteriorly, arborescent tubules 50-53 with well developed dorsal and ventral branches; rostral, marginal and mental pores indistinct; otoliths (sagitta) elongated with well developed anterior and posterior depressions. D.IX, 30-32; A.II, 10-11.

Type:

Otolithus maculatus (Cuvier, 1830).

Distribution:

North east coast of India, Burma, Malay Peninsula, East Indies.

Remarks:

This genus isrepresented by one species from India.

Pterotolithus maculatus (Cuvier)

(Plate V, Fig. 3a)

Otolithus maculatus Cuvier, 1830, Hist. Nat. Poiss., 5:64 (Batavia);-- Valenciennes, 1839, Regne Animal, Poiss., 111, pl.27, fig.2;-- Cantor, 1849, J. Asiat. Soc. Bengal, 18, pt.2:1044 (Malay Peninsula);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:310 (Malay Peninsula);-- Day, 1869, Proc. Zool. Soc. London:300 (Orissa);-- Day, 1878, Fishes of India, pt.2:196, pl.46, fig.4 (Orissa: Lower Bengal);-- Bleeker, 1877, Atlas Ichth. Ind. Neerland., 9(1) 384, fig.3;-- Day, 1889, Fauna Br. India Fish., 2:127, fig.51;-- Lloyd, 1907, Rec. Indian Mus., 1:226 (Akyab);-- Hardenberg, 1934, Treubia, 14:309.

Otolithus bispinosus Cuvier, 1830, Hist. Nat. Poiss., 5:65 (Rangoon);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:310;-- Blyth, 1861, J. Asiat. Soc. Bengal, 29:141 (1860).

Otolithus (Pterotolithus) maculatus Fowler, 1933, U.S. nat. Mus. Bull., 100, 12:359.

Pterotolithus maculatus Mohan, 1972, Indian J. Fish., 16: 82-98;-- Fischer & Whitehead, 1974, F.A.O. Sp. ident Sheets Fish Purposes. Sciaen. Ptero.2.

Material:

5 specimens: Calcutta, 272 mm, (T.L.) female; 181 mm, male; 184 mm, male; 140 mm, female; 135 mm, male; 16-11-68, trawl net.

Description:

D.IX, I, 30-32; P.17-18; A.II, 10-11; C.17. Ll.49-50; Ltr.14-15/1/21-22; G.R.3-4/1/8-9.

Body elongated, snout pointed, lower jaw longer than upper, mouth superior; cleft of mouth oblique, maxillary extending to middle of orbit, preopercle serrated on both arms; upper jaw with two strong curved caninies and lower jaw with one or two caninies on each side; a row of enlarged teeth on both jaws; pharyngeal teeth well developed; rostral pores not distinct, inner and outer marginal pores also indistinct; lower jaw with two median mental pores; inner and outer mental pores absent; gas bladder rounded anteriorly, arborescent tubules about 53, well developed, the dorsal branch with three and the ventral branch with five tubules coverning the bladder dorsally; lateral line terminating at tip of caudal fin, lateral line scales elongated with a pore and a central canal; scales small; cycloid on head and body; dorsal spines weak, third and fourth spines longest, first spine of second dorsal short; caudal fin cuneate, second anal spine weak about one fourth of head; outer ray of pelvic fins longer than inner rays; pectoral fins pointed, paired fins with axillary scales; gill rakers short, inner side with one or two rows of pointed spines. (Plate 5, fig.3b).

Body grey with three or four longitudinal rows of dark spots. Upper margin of dorsal with closely arranged dark pigments, opercle with a blotch.

Detailed morphometric measurements and proportions ~~xx~~ are given in the Table 20.

Distribution:

North east coast of India, Burma, Malayan Peninsula, East Indies, Reaches up to 430 mm.

Remarks

Fowler (1933) created a new sub-genus Pterotolithus to accommodate this species based on the number of anal rays. In the present study it is raised to a generic level based on its structure of otolith (sagitta) and gas bladder which are much different from that of genus Otolithes. Although Munro (1955) extends its distribution to Gulf of Mannar it has not been recorded subsequently from Gulf of Mannar or Palk Bay.

Subfamily : Otolithinae

Gas bladder with well developed arborescent tubules numbering 25-58, antero-lateral expansion absent; teeth differentiated except in Dendrophysa; mental barbels may or may not be present; sagitta elongate with a shallow anterior depression.

Tribe : Otolithini

Gas bladder with 26-50 lateral arborescent tubules. Mental pores on lower jaw not well developed. Outer mental pores distinct. Upper and lower jaws with well developed dentition.

Otolithes Oken

Otolithes Oken, 1782, Isis:1817.

Otolithus Cuvier, 1829, Regne Animal, ed.2, 2:172;-- Trewavas, 1962 Ann. Mag. nat. Hist., (13)5, no.51: 172., - Mohan, 1972, Indian J. Fish., 16:82-98.

Diagnosis:

Body elongated snout depressed; scales moderate to small, ctenoid or cycloid; sensory tubules bifid or arborescent; mouth terminal, wide; lower jaw prominent, preopercle entire or weakly denticulate, upper jaw with inner rows of minute teeth broadening posteriorly and an outer row of closeset conical ones with one or two strong curved canines anteriorly on each sides; lower jaw with well developed canines anteriorly on each side, with inner row of enlarged teeth and an outer row of minute teeth, dorsal fin deeply notched, with nine to ten slender spines and 27-32 rays; anal with 2 spines and 7 rays; caudal rounded or rhomboid; gas bladder oblong, elongated without the antero-lateral expansions and with 26-38 well developed arborescent tubules dividing into dorsal and ventral branches; lateral line pores of the snout not distinct, inner marginal and median marginal pores feebly developed; lower jaw with two median pores and an inner mental pore on each side. Otoliths (sagitta) oblong, anterior and posterior depressions not distinct. D. X-XI, 22-31.

Type:

Johnius cuvieri Trewavas (= *Johnius ruber* Bloch)

Distribution:

Indo-Pacific extending to east coast of China and Japan.

Remarks:

This genus is represented by three species in India.

Otolithes ruber (Schneider)
(Plate V, Fig. 4a)

Otolithus argenteus Cuvier, 1830, *Hist. Nat. Poiss.*, 5:62 (Batavia, Malabar, Malacca);— Cantor, 1850, *J. Asiat. Soc. Bengal*, 18, pt.2: 1043, 1849, (Malayan peninsula);— Gunther, 1860, *Cat. Fish. Br. Mus.*, 2:310 (China, Ceylon) 1861, *Proc. Zool. Soc. London*, 222;— Playfiar, 1866, *Fishes of Zanzibar*; 53 (Aden; mouth of Pangani River, East Africa);— Day, 1878, *Fishes of India*, pt.2:197, pl.45, fig.3;— Bleeker 1877, *Atlas Ichth. Ind. Neerland.*, 9, pl.2:185, fig.5;— Day, 1889, *Fish. Br. India*, 2:129;— Fowler, 1904, *J. Acad. Nat. Sci. Philadelphia*, (2), 12: 530 (Padang);— Pearson, 1912-1913, *Ceylon Adm. Rep*: E 11;- Zugmayer, 1913, *Abh. Bayer. Akad. wiss: math-phys. Kl.*, 26:12 (Makaran);— Pearson, 1915-1918, *Ceylon Adm. Rep*: F.13;— Ogilby, 1918, *Mem. Qld. Mus.*, 6:63, pl.20. (Edgecumbe Bay);— Pillay, 1929, *J. Bombay nat. Hist. Soc.*, 33:366;— Lin, 1935, *Bull. Chekiang Prov. Fish Stn.*, 1:5;— Munro, 1955, *Marine and Fresh water fishes of Ceylon*:156, fig.459.

Otolithes argenteus Jordan and Stark, 1917, Ann. Carnegie Mus., 11:452 (Ceylon);-- Herre, 1931, Notes Fish. Zool. Mus. Stanford Univ:57;-- Fowler, 1933, Bull. U.S. Nat. Mus., 12:355 (Samar, Bacon, Java, Padang, Singapore);-- Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel., 7:429;-- Tang, 1937, Amoy mar. biol. Bull., 2:49 (Amoy);-- Chu, Lo, Wu, 1963, Monogr. Fish. China:45-46;-- Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65:345(Waltair).

Otolithus orientalis Seale, 1911, Philip. J. Sci., 5:281, pl.4, 1910 (Borneo).

Otolithes ruber Fischer and Whitehead, 1974, F.A.O. Sp. ident. Sheets Fish. Purposes. 3: Sciaen. Otol.2.

Material:

3 specimens: Mandapam (Palk Bay); 222 mm, male, 215 mm, male, 222 mm, female (T.L.); Trawl net, 1-11-69; 3 specimens: Kakinada; 198 mm, female, 238 mm, male, 220 mm, male, Trawl net; 10-10-68; 1 specimen: Puthanthurai (near Cape Comorin), 250 mm, female, Hook and Line, 16-4-68;

1 specimen: Neendakarai, (Quilon), 155 mm, female, Trawl net, 15-6-68; 3 specimens: Calicut, 188 mm, female, 214 mm, male, 232 mm, female, Trawl net, 10-10-68; 3 specimens: Waltair, 207 mm, male, 212 mm, female, 201 mm, male, 3-12-68; 1 specimen: Calcutta, 201 mm, female, Trawl net, 3-12-68.

Description

D.X, I, 27-31; P.15-16; C.16-17; A.II, 7; Ll.47-50; Ltr.8-10/1/12-15; G.R.4-5/1/8-10

Body elongated, head pointed, cleft of mouth oblique, mouth terminal. Upper jaw with two or three well developed curved teeth and an outer row of enlarged teeth and an inner row of minute teeth; lower jaw with one or two median canines, an inner row of enlarged teeth and a few minute teeth in between them; gill rakers short and dentate on inner side (Pl.V, fig.4b), first dorsal spine minute, second spine shorter than third; dorsal fin deeply notched, base of median fins without scales; caudal fin cuneate to rhomboid; second anal spine weak, anal fin originates below 14-17 dorsal rays, lateral line pores of snout not distinct, lower jaw with median pores and an inner mental pore on each side (Pl.V, fig.4c) lateral line scales with a central pore; gas bladder with 36-38 well developed arborescent tubules having ventral and dorsal branches; otoliths with anterior and posterior depressions; (Pl.V, fig.4d) cycloid scales on opercle, and base of first dorsal and weakly ctenoid scales on posterior part of body.

Body dorsally grey, ventrally silvery; lower part of caudal fin, pectoral and ventral fins yellowish; upper two third of dorsal fin grey and opercle with dark blotch colour varies.

Detailed morphometric measurements and proportions are given in the Table 21).

Distribution:

East coast of Africa, Madagascar, India, Ceylon, Malay Peninsula, Siam, East Indies, Philippines, Tonkin, South China, Queensland.

Otolithes cuvieri Trewavas

(Plate VI, Fig. 1a)

Otolithus ruber Cuvier, 1830, Hist. Nat. Poiss., 5:60, pl.102 Coromandal coast, Pondicherry & Malabar);-- Cantor,1850, J. Asiat. Soc. Bengl. 18, pt.2:1041, 1849 (Malay Peninsula);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:305, (Malay Peninsula, Karachi);-- Day, 1865, Fishes of Malabar: ~~1865~~1865; Proc. Zool. Soc. London, 19 (Cochin);-- Bleeker, 1874, Verh. kon. Akad. Wet. Amsterdam, 14:11;-- Day,1876, Fishes of India, pt.2:196;-- Day, 1889, Fauna Br. India Fishes, 2:128;-- Elera, 1895, Cat. Fauna Filip., 2:502 (Manila);-- Gilchrist & Thompson, 1908-1911, Ann. S.Afr. Mus., 6:184;-- Fowler, 1926, J. Bombay nat. Hist. Soc., 30:8, (Bombay); 1927, J. Bombay nat. Hist. Soc., 32:260 (Bombay);-- Barnard, 1927, Ann. S. Afr. Mus., 21:573 (South Africa);-- Munro, 1955, Marine and fresh water fishes of Ceylon:156.

Otolithes ruber Jordon and Starks, 1917, Ann. Carnegie Mus., 11:452 (Ceylon);-- Fowler, 1928, J. Bombay Nat. Hist.Soc., 33:115 (Bombay);-- 1933, U.S. Nat. Mus. Bull., 100, 12:

356 (Luzon, Natal, Delagoa Bay, Bombay);-- Weber and de Beaufort 1936, Fish. Indo-Austr. Archipel., 7:490-492;-- Chu, Lo & Wo, 1963, Monogr. Fish. China:46.

Otolithes cuvieri Fischer & Whitehead, 1974, F.A.O. Sp. ident Sheet. Fish. Purpose 3: Sciaen Otol.1.

Material:

1 specimen: Bombay 186 mm, (T.L.) male, trawl net, 17-8-68; 1 specimen: Puthanthurai (North of Cape Comorin), 233 mm, (T.L.) male, Hook & line, 16-4-68; 2 specimens: Keelakarai (Gulf of Mannar), 197 mm, 195 mm (T.L.), females, gill net, 8-5-1971; 1 specimen: Pamban (Gulf of Mannar), 187 mm, male, trawl net, 30-7-71.

Description:

D.IX-X, I, 30-31; P.16-17; A.II, 7; EX C.17; Ll.47-50; Ltr. 8-9/1/12-14; G.R.5-7/1/13.

Body elongated; head broad, snout pointed, lower jaw slightly longer than upper, cleft of mouth very oblique, maxillary extends to middle of orbit. mouth terminal; upper jaw with two or hree canines, an outer row of enlarged teeth and an inner row of minute teeth; lower jaw with one or two median canines, a row of enlarged teeth and minute teeth in between the enlarged teeth; pharyngeal teeth present; preopercle serrated; eyes large, equalling snout; rostral and marginal pores not distinct, lower jaw with two median mental pores and two inner marginal pores (Pl.VI, fig.1c); cycloid scales on cheek, preopercle, opercle, interorbital space, abdomen and base of dorsal fins; ctenoid scales above anal fin and on caudal peduncle; lateral line scales with a pore; gas bladder without the anterior lateral expansions, arborescent tubules 28, short, well developed, anterior tubules not much different from the succeeding ones, dorsal and ventral tubules equally bifurcated; otolith (sagitta) oblong anterior and posterior depressions not distinct (Pl.VI, Fig.1b); second dorsal spine smaller than third, fourth and fifth spines longest dorsal fin deeply notched; second anal spine short and weak; pectoral fins broad extending to base of second dorsal origin, axillary scales present; anal fin originating below 15-16 dorsal ray; caudal fin cuneate; gill rakers slender, long with three rows of pointed simple spines on its inner side.

Body uniformly silvery, two thirds of first dorsal spotted grey, axilla with a blue spot, opercle with a grey blotch; lateral line distinct with a white streak.

Detailed morphometric measurements and body proportions are given in the Table 23.

<u>Distribution:</u>

East Africa, Aden, Mekaran coast, India, Ceylon, Malay Penninsula, Malacca, Siam, East Indies, Tonkin, Sothern China, Philippines, Queensland.

<u>Remarks:</u>

The species is often confused with *O. ruber*. But *O. cuvieri* can be easily identified from *O. ruber* by its larger eyes, smaller canines and higher number of gill rakers.

Otolithes versicolor Cuvier

Otolithus versicolor Cuvier, 1929, *Regne Animal*, 2:173 (on'Potee Kanasah' Russell, 1803, *Fishes of Coromandel*, 2:7, pl.109);--

<u>Description:</u>

D.X, 1, 20-21; P.15-16; A.II, 7; Ll.48-51, G.R.5/1/12.

In standard length height of body at dorsal origin 28.4-31.2, at caudal peduncle 8.4-8.7, length of head 32.5-34.3, diameter of eye 10.5-11.2, snout 8.9-10.0; length of pectoral fin 23.1; length ofventral fin 20.0; (all measurements in percent).

Body compressed, not muchelongated; mouth terminal, strongly oblique, maxillary concealed, lower jaw prominent; two rows of teeth in both jaws, outer row enlarged; three to four canines of moderate size on both jaws; scales cycloid on head and ctenoid on body. Gas bladder rounded anteriorly with 19 pairs of arborescent tubules on each side; snout with three marginal pores and lower jaw with two mental pores. Dorsal fin deeply notched with weak spines, origin of anal fin below tenth dorsal ray, caudal fin rhomboid. Head and body greyish brown, silvery ventrally, tips of dorsal, caudal and pectoral axila dusky, a dark blotch on opercle.

Distribution:

East coast (Visakhapatnam) and West coast (Bombay).

Remarks:

This species seems to be a doubtful species as it is not reported since its original description by Russell (1803).

Genus *Chrysochir* Trewavas & Yazdani

Chrysochir Trewavas and Yazdani, 1966, *Ann. Mag. Nat. Hist.* (13) *8*:249-255 (1965), pl.VI;-- Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Diagnosis:

Gas bladder rounded in front, tapering behind with arborescent tubules on each side; snout acute, overlapping the upper jaw; teeth well differentiated in both jaws, upper jaw with one or two pairs of caniniform teeth; otoliths (sagitta) elongated, thin with an anterior depression and a posterior groove; snout with three rostral pores and distinct marginal pores; lower jaw with six distinct mental pores. D.X, I,25-27.

Type:

Otolithus aureus Richardson, 1846.

Distribution:

India, Malaya, Indo-China and Southern China.

Remarks:

This genus is monotypic.

Chrysochir aureus (Richardson)

(Plate VI, Fig. 2a)

Otolithus aureus Richardson, 1846, *Ichth. China Japan*:224 (Type locality: Canton).

Sciaena ophiceps Alcock, 1889, *J. Asiatic soc. Bengal*, *18*(2): 295-305, pl.22. (Type locality: off deltas of Mahanadi and Godavari).

Johnius birtwistlei Fowler, 1931, *Proc. Acad. Nat. Sci. Philad*: 446 (Type locality: Singapore);— 1933, *Bull. U.S. nat. Mus.*, 100, *12*:403.

Pseudosciaena acuta Tang, 1937, *Amoy mar. biol. Bull.*, *2*(2): 47-88, Fig.5 (Type locality: Hainan, Kwangtung).

Pseudosciaena ophiceps Yazdani, 1966, *J. Zool. Soc. India*, *15*:64-65.

Nibea acuta Lin, 1938, Ling. Sci. J., 17:540, (Kwangtung);— Chu, Lo and Wu, 1963, Monogr. Fish. China:56-57.

Chrysochir aureus Trewavas and Yazdani, 1966, Ann. Mag. Nat. Hist., ser.(13) 8:249-255, pl.6. (Type locality: Orrisa coast, Hong Kong);— Mohan, 1972, Indian J. Fish., 16: 82-98 (Waltair, Madras, Rameswaram).

Otolithoides brunneus Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc. 65:335-347, (Waltair) (Misidentification).

Material:

1 specimen: Kakinada, 287 mm, (T.L.), female, 6-12-68; 5 specimens: Calcutta, 250 mm, female; 170 mm, male; 181 mm, male; 137 mm, male, 220 mm, male, 26-11-68; 1 specimen: Madras, 247 mm, male, 12-12-68.

Description:

D.X, I, 25-27; P.18-19; A.II, 7; C.17; Ll.49-51; Ltr.8-9/1/14-16; G.R.4-5/1/7-8.

Body profile convex, snout pointed, overlapping upper jaw, cleft of mouth slightly oblique; upper jaw with two to four canine teeth anteriorly and an outer row of enlarged and inner rows of minute teeth; lower jaw with outer rows of minute teeth and an inner row of enlarged teeth; pharyngeal teeth well developed; preopercle serrated; snout with three distinct rostral pores and five margianl pores, margin of snout deeply indented at outer marginal and median pores; lower jaw with ~~an~~ 3 pairs of well developed mental pores; gas bladder rounded anteriorly tapering posteriorly extending to vent; arborescent tubules about 24-26, anterior tubules bifurcating into dorsal and ventral branches extending below auditory region, posterior tubules long and bifurcated, otolith (sagitta) elongated, thin and the anterior and posterior depressions distinct (Pl. VI, fig.2 a); ctenoid scales on head and body, lateral line scales with bifurcated tubules; dorsal spines weak, third spine of first dorsal longest, dorsal fin deeply notched; base of second dorsal with a row of scales; caudal fin cuneate in small specimens and obtuse in larger specimens; second anal spine weak, equalling snout; axillary scales well developed; gill rakers short, blunt and dentate (in bigger specimens gill rakers reduce in number and size).

Body grey dorsally, pale brown or with yellow tinge ventrally; dorsal fin with a grey blotch on its upper half; opercle with a blue blotch; posterior ends of caudal fin black in juveniles.

Detailed morphometric measurements and body porportions are given in the Table 23.

<u>Distribution:</u>

India (Calcutta, Waltair, Kakinada, Madras, Rameswaram); Singapore; Kwangtong, Canton.

Pennahia Fowler

Pennahia Fowler, 1926, *J. Bombay nat. Hist. Soc.*, 30:776.

Pennahia Mohan, 1972, *Indian J. Fish.*, 16:82-98.

Diagnosis:

Gas bladder round in front, tapering behind, with about twenty thin lateral arborescent tubules on each side, tubules short, not extending to head; otoliths compressed, wider than long, marginal groove without the posterior depression; rostral pores three, indistinct; marginal pores five; mental pores four - two median pores and an inner pore on its each side; cleft of mouth oblique, snout not overlapping premaxillaries; upper and lower jaws with well developed enlarged teeth. D.X, 21-26.

Type:

Otolithus macrophthalmus Bleeker, 1850.

Distribution:

Arabian coast, India, East Indies, China and Philippines.

Remarks:

This genus is represented by one species from India.

Pennahia macrophthalmus (Bleeker)

(Plate, VIII, Fig.1a)

Otolithus macrophthalmus Bleeker, 1850, *Nat. Tijds. Nederland. Indie.* 1:99 (Batavia).

Sciaena macrophthalmus Gunther, 1860, *Cat. Fish. Br. Mus.*, *2*:291.

Corvina macrophthalmus Bleeker, 1868, *Versl. Meded. Akad. Wet. Amsterdam* (2) *2*:292 (Bintang).

Pseudosciaena macrophthalmus Bleeker, 1874, *Verh. kon. Akad. Wet. Amsterdam*, *14*:21 (East Indies).

Pennahia macrophthalmus Fischer & Whitehead, 1974, F.A.O. Sp. ident. Sheet Fish Purpose 3:

Otolithus aneus Day, 1867, *Proc. Zool. Soc. London*, 939, pl.45, fig.5 (Bombay, Andaman, Madras);— 1889, *Fauna*, *Br. India*, 2: 199;— 1907, *Lloyd*, *Rec. Indian Mus.*, *1*:226 (Akyab);— Pearson, 1915-1918, *Ceylon Adm. Rep.* F.10-F.14.

Pseudosciaena aneus Bleeker, 1877, *Atlas Ichth. Ind. Neerland*: 9, pl.(2) 385, fig.2;— Weber and de Beaufort, 1936, *Fish. Indo-Aust. Archepel.*, *7*:508-510.

Pseudosciaena anea Jordan and Seale, 1907, *Bull. Bur. Fish.*, 26:25(1906) (Cavite).

Argyrosomus aneus Fowlr, 1918, *Copeia*, No.58:64. (Philippines);— Chu Lo & Wu, 1963, *Monogr. Fish. China*:58.

Corvina sina (not Cuvier) Schlegel, 1853, *Fauna Japonica*, *Poiss.*, pts.2-4:58, pl.24, fig.2.

Otolithus leuciscus Gunther, 1972, *Ann. Mag. nat. Hist.*, (4)*10*: 398. (Manila Bay).

Corvina belangerii (not Valenciennes) Evermann & Seale, 1907, Bull. Bur. Fish., 26:87.

Argyrosomus goldmani (not Bleeker) Fowler, 1918, Proc. Acad. Nat. Sci. Philad:43.

Johnius aneus Fowlr, 1933, U.S. Nat. Mus., Bull. 100, 12: 376-378, (Philippines, Borneo, India);— Munro, 1955, Marine and Freshwater fishes of Ceylon;— Dutt and Thankam, 1968, J. Bombay nat. Hist. Soc., 65:336-338.

Pennahia aneus Fowler, 1926, J. Bombay Nat. Hist. Soc., 30(4):776;— Mohan, 1972, Indian J. Fish., 14:85-98.

Pennahia macrocephalus Joglekar and Talwar, 1971, Bombay nat. Hist. Soc., 67(3):575-577.

Otolithus versicolor Talwar and Joglekar, 1970, Rec. Zool. Soc. India, 64, 1-4, 163-167 (Bombay).

Description:

D.X.I, 21-26; P.16-17; A.II, 7; Ll.46-49; Ltr.7-10/1/11-14. G.R.4-6/10-12.

Body spindle shaped, snout pointed, dorsal profile convex, mouth terminal, cleft of mouth very oblique, maxillary extending beyond middle of eye; snout not overlapping premaxillaries; eyes large; preopercle serrated; upper jaw with an outer row of enlarged teeth and inner rows of minute teeth, lower jaw with an outer row of minute teeth and an inner row of enlarged teeth, lower jaw teeth increase in size posteriorly, one or two anterior upper jaw teeth larger than others but not caninoid; pharyngeal teeth well developed, cycloid scales on head and belly, ctenoid scales on caudal peduncle; lateral line scales with bifurcated tubules extending to caudal tip.

Snout with three rostral pores and five indistinct marginal pores; lower jaw with two median mental pores and an inner mental pore on its each side, outer mental pores absent (Pl.VIII, fig.1b); gas bladder rounded anteriorly tapering posteriorly with 15-20 well developed thin arborescent tubules, otolith (sagitta) oblong, anterior depression indistinct, marginal groove deep (Pl.VIII, fig.1c).

Dorsal spines not strong, dorsal fins deeply notched, third and fourth spines longest, last spine of first dorsal shorter than first spine of second dorsal, second anal spine short, weak, nearly equal to eye diameter, first ray of pelvic fin longer, pectoral fins well developed without a distinct pectoral peduncle; base of second dorsal and anal fins without scales; gill rakers moderately developed and dentate on inner side.

Opercle with a steel blue blotch, pectoral axilla with black blotch dorsally, upper 2/3 of first dorsal with a grey blotch.

Detailed morphometric measurements and body proportions are given in the Table 24.

Distribution:

India (Veraval, Bombay, Mangalore, Mandapam, Rameswaram, Madras, Kakinada, Waltair, Calcutta); Singapore, Hong Kong, East Indies, South China.

Remarks:

Joglekar and Talwar (1971) recorded *Pennahia macrocephalus* from the east coast of India. The specimens of *P. macrocephalus* from Hong Kong were examined by me and found to be different from that described by Joglekar and Talwar (*op. cit.*). Hence the above record of *P. macrocephalus* from India doubtful.

Atrobucca Chu, Lo & Wu

Atrobucca Chu, Lo & Wu, 1963, *Monogr. fish. China*:64;— Mohan, 1972, *Indian J. Fish.*, 16:82-98.

Diagnosis:

Gas bladder rounded anteriorly with well developed arborescent tubules, tubules of each side meet dorsally, otolith (sagitta) with a indistinct anterior depression and a distinct posteriorgroove, snout with three rostral pores, five marginal pores, and six mental pores, teeth differentiated in both jaws, mouth terminal. D.X. I, 27-28.

Type:

Sciaena nibe Jordan and Thompson

Distribution:

India, China, Korea and Japan.

Remarks:

This genus is represented by one species from India.

Atrobucca nibe (Jordan and Thompson)

(Plate VIII, Fig. 2a)

Sciaena nibe Jordan and Thompson, 1911, Proc. U.S. Nat. Mus., 39:258 Fig.4 (East coast of Sourthern Japan).

Nibea nibe Jordan and Hubbs, 1925, Mem. Carnegie Mus., 10:243 (Osaka);-- Lin, 1935, Bull. Chekiang Prov. Fish. Expt. St., 1:9 (Chusan).

Pseudosciaena nibe Tang, 1937, Amoy. mar. biol. Bu. 2:67(Foochow).

Argyrosomus nibe Lin 1938, Ling.Sci.J., 17:367 (Chusan,.

Atrobuca nibe Chu, Lo and Wu, 1963, Mongr. Fish China: 64-65, (China);-- Mohan, 1972, Indian J. Fish., 16:82-98. (Calcutta).

Nibea pingi Wang, 1935, Contr. Biol. Lab. Sci. Soc., China, 10:448 (Cheffoo).

Material:

3 specimens: Calcutta, 181 mm, female, 10-11-69; 116 mm, male, 12-11-69; 121 mm, male, 28-11-68.

Description:

D.X, I, 27-28; P.17; C.17; A.II, 7; Ll.48-50; Ltr.8/1/12-15; G.R. 7-8/1/11-12.

Dorsal profile convex, snout swollen but not overlapping the premaxillaries, mouth terminal, oblique, maxillaries extending to posterior end of eyes; eyes large equalling snout, upper jaw with outer rows of teeth enlarged and inner rows of villiform teeth; lower jaw with an ~~ix~~ outer row of minute teeth, and an inner row of enlarged teeth, canines absent, pharyngeal teeth well developed, preopercle serrated.

Snout with three rostral pores and five distinct marginal pores; lower jaw with six mental pores; outer mental pores slit like, inner mental pores round and the median mental pores minute; lateral line scales with bifurcated tubules; scales cycloid on preopercle, opercle, nape and abdomen, ~~and~~ ctenoid below dorsal fins and on caudal peduncle; caudal fin cuneate; a row of scales on base of second dorsal fin; axillary scale present; first ray of pelvic fins filiform; second anal spine weak, less than the orbit; gill rakers dentate, long and pointed. Gas bladder rounded anteriorly with 25-28 well developed, arborescent tubules dorsal and ventral branches well developed and the tubules of each side meet dorsally; posteriorly the gas bladder tapers extending to base of second anal spine; otolith (sagitta) oblong with an indistinct anterior depression and a distinct posterior groove on ventral side.

Body grey dorsally hyaline ventrally, upper edges of first and second dorsal fins grey, tip of caudal fin grey, opercle with a steel blue blotch.

Detailed morphometric measurements and body proportions are given in the Table 25.

Distribution:

India (Calcutta, Waltair); China (South Sea, East Sea, Yellow Sea); South-western Korea, South Western Japan.

Tribe : Argyrosomini

Gas bladder with lateral arborescent tubules but without the antero-lateral expansion.

Argyrosomus de la Pylaie

Argyrosomus de la Pylaie, 1835, Congr. Sci. Fr. Potiers, 1832 & 1833: 524;— Lin, 1940; J. Hong Kong Fish. Res. Stn., 1:243;— Chu, Lo & Wu, 1963, Monogr. fish. China: 57-58.

Pseudosciaena Bleeker, 1863, Nederland Tijdschr. Dierk. 1:142;— Fowler, 1933, Bull. U.S. nat. Mus., 100, 12:368;— Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel, 7:505;— Trewavas, 1962, Ann. Mag. nat. Hist. Soc.,(13)5:172;— Yazdani, 1966, J. Zool. Soc. India, 15:65 (1963);— Trewavas, 1966, Bull. Zool. Nomencl, 23(1):5;— Mohan, 1972, Indian J. Fish., 16:82-98 (1969).

Diagnosis:

Gas bladder round in front without anterior lateral expansions; lateral arborescent tubules about 20, posteriorly gas bladder tapers and extends to anal base; snout with three rostral pores and five marginal pores; free margin of snout not lobulated; lower jaw with six mental pores - two median, one outer and inner mental pore on each side; upper and lower jaws with enlarged teeth; one or two upper jaw teeth caniniform on each side, mouth oblique. D.X, I, 27-29.

Type:

Sciaena aquila Lacepede.

Distribution:

Eastern Tropical Atlantic; Mediterranean, Red Sea, East Africa to West coast of India, Australia.

Remarks:

This genus is represented by one species from India.

Argyrosomus hololepidotus (Lacépède)

Labrus hololepidotus Lacepede 1802, Hist. nat. Poiss. 3:448-518, pl.21. fig.2.

Sciaena hololepidota Cuvier, 1830, Hist. Nat. Poiss., 5:53;— Bleeker, 1864, Nat. Tijds. Nederland. Indie, 21:63;— Guichenot, 1866, Mem. Soc. Sci. Nat. Cherbourg (2):145 (Madagascar);— Barnard, 1927, Ann. S. Afr. Mus., 21:569 (Natal).

Sciaena aquila (Not Lacepede) Gunther, 1860, Cat. Fish. Br. Mus., 2:291 (Algoa Bay);-- Castelnau, 1878, Proc. Linn. Soc. New S.W., 2:232 (Brisbane, Sydney);-- Pellegrin, 1914, Bull. Soc. Zool. France, 39:224 (Madagascar).

Sciaena antarctica Castelnau, 1872, Proc. Zool. Acclimat. Soc., 1:10;-- Waite, 1921, Rec. S. Aust. Mus., 2:107, Fig.164.

Sciaena margaritifera Haly, 1875, Ann. Mag. Nat. Hist. (4): 15:269 (Natal);-- Gilchrist & Thompson, 1917, Ann. Durban Mus., 1:350.

Sciaena hololepidota antarctica Ogilby, 1918, Mem. Qld. Mus., 6:70, pl.21, Brisbane River.

Johnius hololepidotus Seshappa, 1956, Curr. Sci., 25(4):121-122.

Pseudosciaena hololepidota Collignon, 1959, Bull. Inst. Oceanogr Monaco, No.1155:1-10.

Argyrosomus hololepidotus Mohan, 1972, Indian J. Fish., 16:82-98.

Description:

D.X, I,27-29; A.II,7; P.18; C.18; Ll.60-64; Ltr.9-10/1/12-14. G.R.7/1/9.

Head about 4 times in standard length, depth 4.2, eyes 6.0 to 7.0 in head, mandible extending beyond maxillary, maxillary reaching opposite hind edge of eye; lower jaw with an outer row of villiform teeth and inner row of enlarged teeth; upper jaw with inner row of minute teeth and outer row of enlarged teeth. One or two teeth caniniform on each side of the upper jaw; preopercle entire; 5th dorsal spine longest; about one third of head; second anal spine short about one fifth of head; axillary process well developed; scales feebly ctenoid on body, not extending to second dorsal and anal fins. Lateral line scales with tubules extending to caudal fin. Upper jaw with 5 marginal pores, margin of snout not indented, rostral pores indistinct. Gas bladder without the anterior lateral expansions. Caudal fin double emarginate.

Dull grey dorsally, whitish grey ventrally; axilla with a dark blotch.

Distribution:

Eastern tropical Atlantic, Mediterranean, Red Sea, Madagascar, East coast of Africa, Australia and North-west coast of India.

Remarks:

Seshappa (1956) recorded this species from India for the first time. Subsequently it has not been recorded from India and his specimen also could not be traced.

Dendrophysa Trewavas

Denrophysa Trewavas, 1964, *Copeia*:107-117;-- Dutt and Thankam, 1968, *J. Bombay nat. Hist. Soc.*, *65*:342 (Cuvier,1829);-- Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Diagnosis:

Gas bladder oblong, rounded anteriorly, tapering posteriorly arborescent tubules short, 14 or 15; sagitta elongated, oblong with a distinct anterior depression and a curved posterior groove; rostral and marginal pores distinct, mental pores five, upper jaw with enlarged teeth and lower jaw with villiform teeth; lower jaw with a solid mental barbel; gill rakers short. D.X-XI, I, 25-28.

Type:

Umbrina russelli Cuvier, 1829.

Distribution:

India, east Indies, Malaya, Indo-China.

Remarks:

This genus is mono-typic.

Dendrophysa russelli (Cuvier)

(Plate VII, Fig.4a)

Ombrina russelii Cuver, 1829, *Regne animal*, ed.2, 2:174 (on Qualar Katchelee Russell, *Fishes of Coromandal*, *2*:13, pl.118, 1803, type locality:Visagapatnam; (*Ombrina* misprint).

Umbrina russelii Cuvier, 1930, *Hist. Nat. Poiss.*, *5*:178 (Coromandal).

Umbrina russelii Cantor, 1849, J. Asiat. Soc. Bengal, 18:1053 (Malay Peninsula);— Seale, 1910, Philippine J. Sci., 5: 279 (Borneo, Philippines).

Umbrina russellii Gunther, 1860, Cat. Fish. Br. Mus., 1:278 (Malayan Peninsula);— Day, 1878, Fishes of India, pt.2: 183, pl.43, fig.4;— Tirant, 1929, Ser. Oceanogr. Peche Indo-China., note 6:9, 16(169), (Hue'River).

Umbrina rusellii Gorgoza, 1885, Anal. Soc. Espan. Hist. Nat., Madrid, 14:73 (Manila).

Sciaena russelli Bleeker, 1874, Verh.kon. Akad. wet. Amsterdam, 14:58 (East Indies);— Fowler, 1927, Proc. Acad. Nat. Sci. Philad., 79:286. (Philippines);— Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel., 7:544 (East Indies);— Herre, 1953, Check list of Philippine fishes:477;— Munro, 1955, Marine and fresh water fishes of Ceylon: 153;— Chu, Lo and Wu, 1963, Monogr. fish. China:42-43, fig.24 (China).

Sciaena russeli Fowler and Bean, 1923, Proc. U.S. Nat. Mus., 63, art.19:17 Philippines.

Umbrina indica Chaudhuri, 1923, Mem. Indian Mus., 5:725 (Chilka Lake).

Sciaena indica Fowler, 1933, 1933, Bull. 100 U.S. nat. Mus., 12:410 (Manila, Caringo Island and Borneo).

Dendrophysa russelli Trewavas, 1964, *Copeia*:107-117 (Andaman Islands);-- Dutt and Thankam 1968, *J. Bombay nat. Hist. Soc.*, *65*:335-347;-- Sinha and Babu Rao, 1969, *Copeia*:77;-- Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Material:

11 specimens: 160 mm, female, 7-10-67; 147 mm, male, 6-11-68; 155 mm, male, 10-7-69; 139 mm, female, 8-8-69; 135 mm, female, 10-8-69; 123 mm, female, 10-11-70; 109 mm, female, 24-5-71; 112 mm, male, 29-8-71; 96 mm, female, 11-8-70; 112 mm, female, 17-10-71; 96 mm, male, 11-11-71, all from Mandapam.
1 specimen: Calcutta, 155 mm, male, 30-11-68.

Description:

D.X-XI, I.25-28; P.15-17; A.II, 7; C.17, Ll.46-47;Ltr.8-9/1/11-15; G.R.4-5/1/7-8.

Body spindle shaped, dorsal profile convex; cleft of mouth horizontal extending to posterior end of orbit, mout inferior, snout swollen, everlapping the upper jaw, upper jaw with one or two caninoid teeth, an outer row of enlarged teeth and inner rows of villiform teeth, lower jaw with a band of villiform teeth; pharyngeal teeth well developed, preopercle serrated, sensory pores of snout and lower jaw well developed; upper jaw with a cleft like outer marginal pore and a shallow inner marginal pore on each side and a large median marginal pore at the tip of snout; lower jaw with an outer slit-like mental pore, a distinct inner mental pore and a median pore at base of a mental barbel; barbel solid and a filiform; gas bladder rounded anteriorly and tapering posteriorly extending to base of anal fin (Pl. VII, Fig.c); otoliths (sagitta) broad anteriorly and narrow posteriorly, with an indistinct anterior depression and a posterior distinct curved groove (Pl.VII, Fig.4b); lateral line scales with branched tubules; cycloid scales on cheeks and ctenoid scales on preopercle, opercle, nape and body; dorsal spines not robust, second spine shorter than third, fourth and fifth longest, second dorsal spine longer than last spine of first dorsal, caudal fin wedge shaped; second anal spine robust almost equals first anal ray; first ray of pelvic fin filiform; gill rakers short and dentate.

Body hyaline, a dark brown broad band on nape, opercle with a deep blue blotch, first dorsal with a grey bloch.

Detailed morphometric measurements and body proportions are given in Table 26.

<u>Distribution</u>:

India (East and West Coasts), Ceylon, Malay Peninsula, East Indies, Philippines, Indo-China, Amoy.

<u>Remarks</u>:

In the structure of gas bladder and otoliths (sagitta) *D. russelli* resembles to species of *Nibea* Jordan and Thompson. But its dentition and sensory pores on snout differ from the ~~above~~ above genus.

Nibea Jordan and Thompson

Nibea Jordan and Thompson, 1911, *Proc. U.S. nat. Mus.*, *39*: 244, 246;— Chu, Lo & Wu, 1963, *Monogr. fish. China*: 47;— Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Diagnosis:

Body elongated, mouth terminal or subterminal, snout with 3 rostral pores and five marginal pores; lower jaw with six mental pores; gas bladder rounded anteriorly without the anterior lateral expansions, arborescent tubules 20-25; otoliths (sagitta) elongated with an inner anterior depression and posterior groove; jaws with enlarged teeth and one or two rows of minute teeth; dorsal fin deeply notched; D.IX-X, I, 24-31.

Type:-

Pseudotolithus mitsukurii Jordan and Snyder.

Distribution:

Japan, Philippines, China, Australia, Malay Peninsula, India, East coast of Africa.

Remarks:

This genus is represented by six species from India.

Nibea soldado (Lacépède)
(Plate VI, Fig.1a)

Holocentrus soldado Lacépède, 1802, *Hist. Nat. Poiss.*, *4*: 344, 389 (type locality: 'Cayenne').

Corvina soldado Cantor, 1850, *J. Asiat. Soc. Bengal*, *18*:1052, 1849 (Pinang)

Corvina miles Cuvier, 1829, *Regne Animal*, ed. 2, *2*:173 (on Tella Katchele, Russell, *Fishes of Coromandal* *2*:13, pl.117, 1803, type locality: Vizagapatanam);— Gunther, 1860, *Cat. Fish. Br. Mus.*, *2*: 1860 (Ceylon & Malay Peninsula).

Sciaena miles Cuvier, 1830, *Hist. Nat. Poiss.*, *5*:94 (Pondicherry; Java);— Valenciennes, 1833, *Hist. Nat. Poiss.*, *9*:479;— Day, 1878, *Fishes of India*, pt.2:185, fig.5 (Bombay);— 1889, *Fauna Br. India Fishes*, *2*:113;— Lloyd, 1907, *Rec. Indian Mus.*, *1*:226 (Akyub);— Tirant, 1929, *Ser. Oceanogr. Pech. Indo-Chine* Note 6:169 (Saigon).

Sciaena soldado Barnard, 1927, *Ann. S. Afr. Mus.*, 21: pt.*2*: 570 (East Africa).

Nak soldado Chu, Lo & Wu, 1963, *Monogr. Fish. China*:29.

Nibea soldado Mohan, 1972, *Indian J. Fish.*, *16*:82-96.

Psuedosciaena soldado Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archepel.*, *7*:520.

Johnius soldado Fowler, 1933, *Bull. U.S. nat. Mus.*, *12*:392;— Munro, 1955, *Marine and Fresh Water Fishes of Ceylon*: 155;— Smith, 1961, *Sea Fishes of South Africa*, 4th Edn. 226.

Johnius miles Bleeker, 1861, Versl. Meded. Akad. Wet. Amsterdam 12:73 (Pinang);-- Fowler, 1925, J. Bombay nat. Hist. Soc., 30:320 (Bombay).

Pseudosciaena miles Bleeker, 1874, Verh. kon. Akad. Wet. N Amsterdam 14:25 (Pinang, Java, Borneo, Celebes).

Corvina wolffii Bleeker, 1851, Nat. Tijds. Nederland Indie, 2:66 (Bandjermassing).

Corvina sampitensis Bleeker 1852, Nat. Tijds. Nederlnd. Indie, 3: 421 (South Borneo).

Corvina celebica Bleeker 1854, Nat. Tijds Nederland Indie, 7: 244 (Celebes).

Corvina dorsalis Peters, 1855, Arch. Naturg., pt.1:242 (Mozambique);-- Sauvage, 1891, Hist. nat. Madagascar: 350, pl.17, fig.3-3a.

Material:

6 specimens: Mandapam, 160 mm, female, 24-4-68; 210 mm, male, 7-10-69; 168 mm, female, 10-7-69; 156 mm, male, 10-10-71; 126 mm, female 4-7-71; 93 mm, female, 10-7-72; 1 specimen: Keelakarai, (Gulf of Mannar), 168 mm, female, 21-12-67; Trawl net; 1 specimen: Calcutta, 215 mm, male, 12-11-68, Trawl net.

Description:

D.X, I, 28-30; P.15-16; A.II, 7; C.17; Ll.47-49; Ltr.9-10/1/13-16; G.R.5/1/8-10.

Dorsal profile strongly convex, cleft of mouth slightly oblique extending to posterior end of eye; snout not overlapping, lower jaw, eyes much above the tip of cleft of mouth; upper jaw with an inner row of enlarged teeth and an outer row of villiform teeth, lower jaw with an inner row of enlarged teeth and an outer row of minute teeth; pharyngeal teeth well developed, canines absent; preopercle serrated on both arms, with two weak spines; gas bladder without anterolateral expansions tapering posteriorly as a narrow tube extending to base of second anal spine; arborsecent tubules short 20-22, first tubules longer (pl. VI, fig.3c); otoliths slightly ~~xx~~ elongated, anterior inner depression distinct, posterior groove deep and curved, outer side granulated (Pl.VI, fig. 3b); lateral line scales with a branched tube; cycloid scales on cheeks, preopercles and opercles and ctenoid scales on body.

First dorsal spine minute, third and fourth spines longest, spines not strong, dorsal fin deeply notched; second anal spine robust and long; pectoral fins well developed; first spine of pelvic fins strong; caudal fin cuneate in smaller specimens and rhomboid in large specimens; gill rakers short and pointed with minute spines on inner side.

Body hyaline or light grey above and silvery below, paired and caudal fins yellowish; first dorsal, upper two thirds of second dorsal and tip of caudal fin dark grey; a blue blotch on opercle; base of each dorsal spine and ray with a dark spot.

Detailed morphometric measurements and body proportions are given in the Table 27.

Distribution:

Mozambique, Madagascar, India, Ceylon, Malay Peninsula, East Indies, Indo-China, South China, and Philippines.

Nibea albida (Cuvier)

(Plate VI, Fig.4a)

Corvina albida Cuvier, 1830, Hist. nat. Poiss., 5:93 (Pondicherry, Mahe, Malabar);— Valenciennes, 1834, Voy. Indi. Orient., Belanger Zool:355 (Mahe, Pondicherry).

Pseudosciaena albida Bleeker, 1863, Ned. Tijdschr. Dierk., 1:145 (Amoy);— 1865, 2:56 (Amoy).

Sciaena albida Day, 1878, Fishes of India pt.2:188, pl.44, figs.4-6, (Calcutta);— 1889, Fauna Brit. India, Fishes 2:117;— Malpas, 1921, Ceylon Adm. Rep. B8;— Hardenberg, 1931, Treubia, 13:131 (Sumatra).

Johnius anei (not Bloch) Blyth, 1860, Proc. Asiat. Soc. Bengal, 29:141 (Sittang River).

<u>Corvina neilli</u> Day, 1865, <u>Fishes of Malabar</u>:54 (Cochin).

<u>Sciaena coibor</u> Chaudhuri, 1923, <u>Mem. Indian Mus.</u>, <u>5</u>:724 (Chilka Lake)

<u>Johnius coibor</u> Fowler, 1933, <u>U.S. natn. Mus. Bull.</u> 100, <u>12</u>:378;-- Munro, 1955, <u>Marine and fresh water fishes of Ceylon</u>:154.

<u>Pseudosciaena coibor</u> Weber and de Beaufort, 1936, <u>Fish. Indo-Austr. Archipel.</u> <u>7</u>:517;--

<u>Dendrophysa hooghliensis</u> Sinha & Rao, 1969, <u>Copeia</u>: 77(Calcutta).

<u>Dendrophysa albida</u> Talwar, 1970, <u>Proc. Indian Acad. Sci.</u>, <u>72</u>:201-206.

<u>Daysciaena albida</u> Talwar, 1970, <u>Proc. Zool. Soc. Calcutta</u>, <u>23</u>:191.

<u>Material</u>:

7 specimens: 231 mm, female, 4-12-68; 225 mm, female, 12-11-69; 220 mm, male, 1212-68; 236 mm, male, 4-12-68; 228 mm, female, 16-11-68; 265 mm, male, 16-11-68; 191 mm, male, 10-12-68; 187 mm, male, 18-7-70; all specimens from Calcutta.
1 specimen: Waltair, 327 mm, male, 3-12-69.

<u>Description</u>:

D.IX-X, I, 23-24; P.16-18; A.II, 7; C.16-17;

Ll.49-52; Ltr.8-11/1/12-15; G.R.4-5/1/8-10.

Dorsal profile convex, mouth sub-terminal, slightly oblique, extending to posterior end of orbit, snout not overlapping the jaws; teeth differentiated in both jaws; upper jaw with an outer row of enlarged teeth and an inner row of minute teeth; lower jaw with outer rows of villiform teeth and an inner row of enlarged teeth; canines absent. Pharyngeal teeth well developed preopercles serrated, lower jaw with a short barbel on each side (Pl.VI, Fig.4c). Gas bladder rounded anteriorly, arborescent tubules 18-19, first tubules short with inner and outer branches; otoliths (sagitta) thick, anterior and posterior depressions distinct, the latter deep and curved (Pl.VI, Fig.4b); lateral line scales with a pore.

First dorsal spine short and robust, second spine shorter than third, third and fourth longest; last spine of first dorsal shorter than first spine of second dorsal; second anal spine strong, equalling postorbital length; base of second dorsal and anal fins with two rows of scales; cycloid scales on cheeks, opercles and preopercles, ctenoid scales on other parts of body; gill rakers short with two rows of simple short spines on one side.

Greyish dorsally, silvery ventrally with faint oblique lines; head dorsally brown,paired fins yellowish, spinous dorsal black, second dorsal with a black upper edge.

Detailed morphometric measurements and body proportions are given in the Table 28.

Distribution:

Penang, Sumatra, Karachi, Java, India (Malabar coast, Coromandal coast, Chilka Lake), Ceylon, Java. In seas and estuaries.

Remarks:

Hamilton (1822) while describing Bola coibor observed three anal spines in anal fin. It may not be a sciænid fish since it has three anal spines. Sinha and Rao (1969) described a new species Dendrophysa hooghliensis which is a synonym of Nibea albida. Talwar (1970a) created a new genus Daysciaena based on its minute mental barbels. As ~~msx~~ structure of gas bladder, otoliths and dentition are taken as the basis of classification of sciaenid fishes, this genus which is based on the presence of two minute mental barbels is not recognised here.

Nibea chui Trewavas

Pseudosciaena coibor (nec. Hamilton) Tang. 1937, Amoy. mar. Biol. Bull: 2:47-68 (China).

Nibea coibor (nec. Hamilton) Chu, Lo & Wu, 1963, Monograph of fishes of China, 48, fig.26, 52, 78 (China).

Nibea chui Trewavas, 1971, J. Fish. Biol., 3:453-461 (Hong Kong, Japan).

Material:

1 specimen: Bombay, 388 mm, male, 20-11-72.

<u>Description</u>:

D.XI, I, 24; P.17; A.II, 7; Ll.50;

Ltr.9/1/14; G.R.5/1/13.

In standard length height at dorsal origin 27.4, at anal origin 21.0, at caudal peduncle 8.2, head length 31.1. In head eye 17.1, snout 24.2, upper jaw 40.4, lower jaw 31.3, second dorsal spine 35.5, third dorsal spine 47.4, second anal spine 42.4, pectoral fin 73.7, caudal fin 73.7; all measurements in percent.

Body spindle shaped, dorsal profile ascending gradually, head pointed, mouth terminal, cleft of mouth slightly oblique, snout not overlapping lower jaw lower jaw with an inner row of enlarged teeth and outer rows of minute teeth, upper jaw with an outer row of well developed teeth and inner rows of minute teeth; canines absent; preopercle serrated; rostral pores and marginal pores of snout not distinct, lower jaw with five distinct mental pores; free margin of snout shallowly indented; gas bladder rounded anteriorly, arborescent tubules 18; lateral line scales with a central pore; first dorsal spines strong, second anal spine robust about 42 per cent of head; pectoral fins well developed; scales ctenoid on head and body; gill rakers dentate and shorter than half of eye; upper portion of first dorsal light grey, body uniformly hyaline.

Detailed morphometric measurements and body proportions are given in the Table 29.

Distribution:

Japan, China, Hong Kong, Bombay.

Remarks:

This species is confused with *Nibea albida* Cuvier due to the apparent similarities though *N. chui* does not have the minute mental barbels.

Nibea semiluctuosa (Cuvier)

(Plate VII, Fig.1a)

Corvina semiluctuosa Cuvier, 1830, *Hist. Nat. Poiss.*, 5:106, Malabar, Goa, Pondicherry);— Day, 1865, *Fishes of Malabar*:53.

Johnius semiluctuosa Bleeker, 1874, *Verh. kon. Akad. Wet. Amsterdam*, 14:1874.

Sciaena semiluctousa Day, 1878, *Fishes of India*, pt.2:191 (Bombay, Sind);— 1888, *Fauna Br. India*, 2:121; Zugmayer, 1913, *Abh. Bayer. Akad. Wiss., math.-phys. Kl.*, 26, pt.6:12 (Mekaran).

Nibea semiluctuosa Trewavas, 1971, *J. Fish. Biol.*, 3:453-461;— Mohan, 1972, *Indian J. Fish.*, 16:82-97.

Material:

4 specimens: 269 mm (T.L.), female, 4-11-72; 225 mm, male, 4-11-72; 206 mm, male, 4-11-72; 197 mm, male, 4-11-72; all the specimens from Veraval. 2 specimens: Bombay, 217 mm, male, 26-10-72; 320 mm, male, 4-4-72.

Description:

D.IX-X, I, 28-29; P.18; A.II, 7; C.17, Ll.53-56; Ltr. 12-13/1/19-22; G.R.3-5/1/5-7.

Body spindle shaped, dorsal profile convex; head pointed, mouth subterminal, snout not overlapping premaxillaries; cleft of mouth slightly oblique, lips prominent; eyes large, above the level of tip of mouth; upper jaw with an outer row of enlarged teeth and inner rows of minute teeth, anterior outer row teeth well developed; lower jaw with outer rows of minute teeth and an inner row of enlarged teeth; pharyngeal teeth well developed; margin of preopercle smooth; snout with 3 rostral pores and five marginal pores and lower jaw with five mental pores; margin of snout deeply indented; scales strongly ctenoid on head and body; minute scales at the base of second dorsal, pectoral and pelvic fins; lateral line scales with a pore and a branched tube; gas bladder rounded anteriorly, lateral arborescent tubules 20-21, short, dividing into dorsal and ventral branches, first tubules embedded in a membrane of the bladder; otolith elongated with a shallow anterior depression and distinct posterior groove (Pl.VII, Fig.1b). Dorsal spines strong, first dorsal continuous with second dorsal, first spine of second dorsal as high as last spine of first dorsal, second anal spine robust; caudal fin cuneate, first ray of pelvic fin filiform; gill rakers short, pointed, dentate on one side.

Head grey, lips white, dorsal, pelvic, pectoral and caudal fins black; each row of scales with black streak giving body a dark grey colour.

Detailed morphometric measurements and body proportion are given in the Table 30.

Distribution:

North west coast of India, and Mekaran coast.

Remarks:

In India, its distribution is restricted to North west coast only.

Nibea diacanthus (Lacépède)
(Plate VII, Fig.2a)

Lutjanus diacanthus Lacepede, 1802, *Hist. Nat. Poiss.*, 4:195-240

Johnius diacanthus Cantor, 1849, *J. Asiat. Soc. Bengal*, 18: 1049 (Malay, Penninsula);-- Fowler, 1926, *J. Bombay nat. Hist. Soc.* 30:777 (Bombay);-- 1928, 3:115 (Bombay);-- *Proc. Acad. nat. Sci. Philad.*, 1929 (1930).

Sciaena diacanthus Gunther, 1860, Cat. Fish. Br. Mus.,2:290 (China, Bay of Bengal);-- Day, 1865, Proc. Zool. Soc. London:18 (Malabar);-- 1878, Fishes of India:189 (Calcutta);-- Karoli, 1881 Termisz. Fuzetek Budapest, 5:159 (Singapore);-- Pillay, 1929, J. Bombay nat. Hist. Soc., 33:366.

Pseudosciaena diacanthus Bleeker, 1874, Verh. kon. Akad. Wet. Amsterdam, 14:27 (Singapore, east Indies);-- Weber and de Beaufort, 1936, Fish. Indo-Austr. Archipel., 7:515 (Singapore, East Indies);-- Tang, 1937, Amoy mar. biol. Bull., 2:58 (Foochow).

Nibea diacanthus Lin, 1938, Ling. Sci. J., 17:544 (Chusan);-- Chu, Lo and Wu, 1963, Monogr. Fish. China:52 (China);-- Mohan, 1972, Indian J. Fish., 16:82-95.

Johnius cataleus Cuvier, 1829, Regne Animal, ed.2, 2:173, (on Katchelee Russell, Vizagapatnam);-- Valenciennes, 1839 Regne Animal, Cuvier, ed.3., Poiss:81.

Corvina catalea Cuvier, 1830, Hist. Nat. Poiss., 5:128 (Pondicherry; Malabar);-- Richardson, 1846, Ichth. China. Japan:222 (China).

Sciaena muculata (Not Bloch) Gray, 1832, Illustr. Indian Zool.2., pl.89, fig.1 (India);-- Gunther, 1860, Cat. Fish. Br. Mus., 2:291.

Johnius maculatus Blyth, 1860, J. Asiat. Soc. Bengal, 29: 141 (Sittang River).

Pseudosciaena maculata Tang (not Bloch), 1937, Amoy. mar. biol. Bull., 2:55 (Foochow).

Johnius valenciennii (Eydoux and Souleyet) 1841, Voy. Bonite, Zool. 1:159, pl.1, fig.2 (China).

Pseudosciaena goma Tanaka, 1915, Zool. mag. Tokyo, 27:615 (Nagasaki);— Tang, 1937, Amoy mar. biol. Bull., 2:57, fig.3 (Foochow).

Corvina nigromaculata Borodin, 1930, Bull. Vanderbilt mar. mus. 1:53, pl.2 (Ceylon).

Nibea taipingensis Herre, 1932, Ling. Sci. J., 11:436 (Kwangtung)

Nibea goma Lin, 1934, Bull. Chekiang Prov. Fish Expt. Stn., 1:15, fig.8;— Lin. 1938, Ling Sci. J., 17:543.(Shantung).

Material:

3 specimens: 302 mm, male; 251 mm, female; 180 mm, indeterminate; all from Mandapam collected on 11-1-68. 1 specimen: Keelakarai (Gulf of Mannar), 144 mm, female, gill net, 18-11-71. 2 specimens: 281 mm, male, 212 mm, female, teawl net from Kakinada, collected on 8-10-68. 5 specimens: 184 mm, male, 16-10-68; 200 mm, male, 8-10-68; 167 mm, juvenile, 8-11-68; 156 mm, male, 8-10-68; 191 mm, female, 10-11-68; all from Calcutta. 1 specimen: Bombay, 295 mm, female, 18-6-67.

Description:

D.IX-X, I,22-25; P.17-18;C.17; A.II; 7-8;V.1,5;
Ll.49-52; Ltr.9-12/1/15-17; G.R.4-5/1/6-8.

Dorsal profile convex, head pointed, spindle shaped; maxillary extending to posterior end of eye, cleft of mouth slightly oblique, snout not overlapping upper jaw; upper jaw with an enlarged outer row of teeth and inner row of minute teeth, two or three teeth on each side of upper jaw caninoid; lower jaw with an inner row of enlarged teeth and an outer row of minute teeth; pharyngeal teeth well developed; preopercle serrated in smaller specimens; lateral line scales with a central pore and branched tubules; gas bladder rounded anteriorly with 19-20 arborescent tubules on each side, ventral and dorsal branches of the tubules well developed, anterior branches short; otoliths (sagitta) oblong, anterior depression distinct, posterior groove curved and deep (Pl.VII, Fig.2b); scales ctenoid on head and body; dorsal spines strong, second spine shorter, third and fourth longest, last spine of first dorsal shorter than first spine of second dorsal; second dorsal base with two rows of scales; caudal fin cuneate; second anal spine not robust; first rays of pelvic fins filiform; gill rakers short, slender with 2-3 rows of short spines on inner side, in specimens above 200 mm gill rakers short and blunt without spines.

Colour highly variable, smaller specimens have 3 or 4 dark grey bands and grey spots all over the body. Specimens above 280 mm have fewer spots and the indistinct bands, paired fins black; in specimens above 400 mm, body hyaline and pectoral fins light grey.

Detailed morphometric measurements and body proportion are given in the Table 31.

Distribution:

India, Ceylon, Malay Peninsula, East Indies, Philippines, China.

Remarks:

Bola chaptis Hamilton which was synonymised with Nibea diacanthus (Lacepede) has been found to be a distinct species (Trewavas and Talwar, 1972). Trewavas & Talwar (op.cit.) proposed a genus Protonibea to accommodate 'diacanthus' But this genus is considered to be a subjective synonyme of Nibea.

This species grows to 120 cm or more and forms a fishery mainly in north west-coast of India and in Gulf of Mannar.

Nibea bleekeri (Day)

Sciaena (Pseudosciaena) bleekeri Day, 1876, Fish. India 185 pl.45, fig.4 (Bombay).

Johnius argentatus Fowler (partim) U.S. Natn. Mus. Bull. 100 12: 394-396.

Argyrosomus bleekeri Talwar and Joglekar, 1972, *Rec. Zool. Surv. India*, *66*:1-5.

Johnieops bleekeri Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Description:

D.X, I, 26-27; P.17, A.II, 7, Ll.60,
Ltr.9-10/1/18. G.R.5 + 9.

In standard length, height at dorsal origin 26.5; length of head 31.1. In head length eye diameter 25.5, snout 25.5, interorbital space 19.1, length of maxilla 40.4, length of second anal spine 27.6; measurements in percent.

Dorsal profile convex; snout not overlapping premaxillaries, cleft of mouth oblique, maxilla reaching beyond half of eye; eyes above the level of tip of maxilla; preopercle strongly serrated; snout with 5 marginal pores, lower jaw with five mental pores; upper jaw with an outer row of enlarged teeth and inner rows of villiform teeth, lower jaw with an inner row of enlarged teeth and outer rows of minute teeth; one or two anterior upper jaw teeth caninoid; scale small, cycloid on head and ctenoid on body, lateral line scales with tubules; gas bladder rounded anteriorly with 29 pairs of arborescent tubules on each side; second anal spine seak, about half the length of first ray and more or less equals to eye diameter; caudal wedge shaped.

Body dorsally grey and ventrally hyaline, upper part of first dorsal light grey.

Distribution:

Bombay and Gwadur.

Remarks:

This species has been synonymised with *Sparus argenteus* Houttuyn, *Argyrosomus iharae* Jordan and Metz, *Nibea nibe* Jordan and Hubbs by Fowler (1933); with *Pseudosciaena indicus* Tang by Lin (1940) and Talwar and Joglekar (1972). But *Nibea bleekeri* Day seems to be a distinct species from all the above mentioned species due to its smaller scales (lateral line series 60 and lateral transverse scales 9-10/18). All the other above-mentioned species have much less lateral line series (48-50) and less lateral transverse scales (5-6/10-12).

Nibea maculata (Schneider)

(Plate VII, Fig. 3a)

Johnius maculatus Schneider, 1801, *Syst. Ichth. Bloch*:75 (Tranquebar);— Jordan and Starks 1917, *Ann. Carnegie Mus.* II:453 (Ceylon);— Fowler 1933, *U.S. Natn. Mus. Bull.*, 100, *12*:380;— Weber and de Beaufort, 1936, *Fish. Indo-Austr. Archipel.* I:538;— Munro, 1955, *Marine and Fresh Water Fishes of Ceylon*:154.

Corvina maculata Cuvier, 1830, *Hist. Nat. Poiss.*, *5*:126
(Pondicherry);-- Jerdon, 1851, *Madras J. Lit. Sci.*132.

Sciaena maculata Gunther, 1860, *Cat. Fish. Br. Mus.*, *2*:291;--
Day, 1878, *Fishes of India*, pt.2:190 (India);-- XXXX
1889, *Fauna Bri. India. Fishes*, *2*:119.

Nibea maculata Dutt and Thankgam, 1968, *J. Bombay nat. Hist. Soc.*, *65*(2):335-347.

Nibea maculatus Mohan, 1972, *Indian J. Fish.*, *16*:82-98.

Material:

8 specimens: 227 mm, female, 11-8-69; 207 mm (T.L.), male, 10-1-69; 236 mm, male, 10-8-67; 185 mm, female, 18-8-69; 131 mm, female, 10-7-69; 191 mm, female, 31-7-68; 151 mm, male, 8-10-70; 115 mm, male, 8-10-70; all from Mandapam (Palk Bay) Trawl net. 1 specimen: Puthalam (South west coast of India) 199 mm, female, 10-11-69. 1 specimen: Tuticorin 164 mm, female, Trawl net, 31-7-67. 1 specimen: Madras 192 mm, male, gill net, 4-7-68; 1 specimen: Pamban (Gulf of Mannar), 137 mm, female, trawl net, 7-5-70.

Description:

D.X, I. 22-26; P.16-17; A.II, 7; C.17; Ll.48-51; Ltr.11-13/1/17-21; G.R.4-5/1/6-8.

Body spindle shaped, dorsal profile convex; head pointed; cleft of mouth inferior, extending to posterior half of eye;

eyes above the level of tip of mouth; snout overlapping lower jaw; lower jaw with a band of villiform teeth and an inner row of enlarged teeth, anterior upper jaw teeth caninoid, pharyngeal teeth well developed; preopercle weakly serrated, sensory pores of snout well developed; tip of snout with three rostral pores and five marginal pores; gas bladder rounded anteriorly with 19-21 arborescent tubules, anterior tubules longer; otolith (sagitta) oblong, anterior depression indistinct, posterior groove curved and distinct (Pl.VII, fig.3b); lateral line originating above opercle and terminating at caudal tip; second dorsal spine shorter than third spine; fourth and fifth spines longest, last spine of first dorsal shorter than first spine of second dorsal; dorsal fin notched deeply; caudal fin biconcave; second anal spine not strong, about 1/3 of head; first ray of pelvic fins filliform; gillrakers short and dentate.

Body light grey; upper first dorsal dark grey, nape with a grey blotch extending to base of opercle, four dark grey bands over the body of which the first two extend below the lateral line.

Detailed morphometric measurements and body proportions are given in the Table 32.

Distribution:

Ceylon, India, Mekaran coast, Penang.

TABLE 1

Morphometric characters of Johnius carutta (Bloch)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	180	170	148	160	126	157	135	107	107	152	103	128	129	88	114	In standard length				
Ht.at D.origin	60	52	43	51	38	45	41	44	43	46	32	38	38	28	34	28.6-33.3	30.5	1.35	0.348	4.4
Ht.at A.origin	43	38	33	36	29	35	32	26	25	35	25	30	31	21	27	22.3-24.3	23.3	0.71	0.183	3.0
Ht.at C.peduncle	19	16	14	15	12	15	13	10	11	15	10	13	12	9	11	9.3-10.5	9.7	0.39	0.100	4.1
Head length	60	55	46	51	39	49	42	32	31	46	41	40	39	28	36	28.9-33.3	31.1	1.07	0.276	3.5
Predorsal length	61	54	48	52	40	52	41	34	33	48	34	42	42	30	38	30.4-34.1	32.4	1.05	0.271	3.2
																In ~~eye diameter~~ head length				
Eye diameter	12	12	11	11	9	10	10	8	8	10	8	9	8	7	6	20.0-25.8	22.9	1.93	0.496	8.4
Snout length	14	12	10	12	8	11	8	7	7	10	8	9	11	6	8	20.5-25.8	22.5	1.32	0.342	5.9
Inter orb-space	19	17	15	16	12	16	14	10	10	14	10	13	12	9	11	30.5-33.3	31.7	0.99	0.255	3.1
Upper jaw length	21	20	16	18	14	17	15	11	11	16	11	14	14	10	12	33.3-36.3	35.2	1.35	0.348	3.8
Lower jaw length	15	13	11	15	11	13	17	8	9	12	9	10	12	9	10	23.9-32.1	27.2	2.54	0.656	9.4
Second D.Spine	32	30	25	26	27	25	25	22	23	25	19	23	25	16	23	50.9-24.2	59.2	6.71	1.733	11.3*
Third D. spine	32	27	25	26	25	27	23	20	21	24	18	23	25	16	21	49.1-67.7	57.3	5.21	1.345	9.1
Second anal spine	14	14	14	14	12	14	12	11	11	11	13	12	13	10	11	23.9-41.9	30.6	1.88	0.486	6.1
Pectoral fin	43	41	35	41	30	37	33	25	26	37	24	32	30	21	28	71.6-83.9	77.5	2.49	0.643	3.2
Caudal fin	33	30	26	30	29	30	--	21	25	29	23	25	25	21	23	54.5-80.6	64.9	7.85	2.028	12.1*
																In eye daimeter				
Longest G.raker	1	1	1	1	1	1	.5	1	--	.5	.5	.5	.5	.5	.5	5.0-12.5	7.8	2.23	0.576	28.5**
Sex	F	M	F	M	M	F	F	F		M	M	M	M	M	M	**Highly variable;*variable				
Locality	PIM	MMM	MMM	MMM	MMM	MDS	MDS	TTN	MMM	VGM	TTN	KKN	KKN	KKN	KKN	PIM=Puthalam;MMM=Mandapam MDS= Madras; TTN= Tuticorin VGM= Vizhinjam;KKN=Kakinada				

TABLE 2

Morphometric characters of Johnius glaucus (Day)

(Measurements in mm)

	1	2	3	4	5	6	7	8	Range (%)	Mean (%)	S.D.	S.E.	C.V (%)
Standard length	143	182	185	164	153	139	111	111	In standard length				
Ht.at D.origin	44	61	55	57	50	44	35	35	29.7-34.7	32.1	4.90	1.737	15.3**
Ht.at A.origin	33	43	45	41	37	32	25	25	22.5-24.1	23.5	0.84	0.297	3.5
Ht.at C.peduncle	15	18	18	17	18	14	10	11	9.0-10.4	9.8	0.51	0.520	5.2
Predorsal length	46	58	62	54	47	41	37	34	29.4-30.5	31.7	2.71	0.960	6.5
Head length	45	58	60	52	47	42	37	36	30.2-33.3	31.9	1.41	0.500	4.4
									In head length				
Eye diameter	12	14	15	15	12	12	10	11	24.1-30.5	27.0	2.01	0.712	7.4
Snout length	7	13	13	10	9	8	8	7	15.5-21.6	19.7	2.27	0.804	11.5*
Inter orb-space	12	17	17	15	15	13	10	11	26.6-31.9	29.1	3.14	1.114	10.8*
Upper jaw length	17	22	22	21	20	19	14	14	36.6-45.2	39.5	3.80	1.347	9.6
Lower jaw length	17	20	20	19	17	17	12	12	33.3-40.4	35.5	2.70	0.957	7.6
Second dorsal spine	—	27	22	—	—	—	16	17	43.2-47.2	45.6	2.43	0.861	5.3
Third dorsal spine	20	27	—	22	19	19	16	18	40.4-50.0	44.5	3.84	1.361	8.6
Second anal spine	14	15	16	—	14	13	12	11	25.8-32.4	29.4	3.06	1.085	10.5*
Pectoral fin length	35	44	43	41	35	34	27	25	69.4-80.9	27.2	1.170	0.415	1.6
Caudal fin length	33	38	37	35	37	37	31	27	61.6-88.0	73.3	8.69	3.081	11.8
Sex	F	F	F	F	F	F	M	M	* Variable				
Locality	BMY	VRL	VRL	VRL	BMY	BMY	BMY	BMY	BMY = Bombay; VRL = Veraval				

TABLE 3

Morphometric characters of the <u>Johnius coitor</u> (Hamilton)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Range (%)	Mean (%)	S.D.	S.E.	C.V (%)
Standard length	136	142	147	112	105	110	113	86	90	142	116	96	In standard length				
Ht.at D.origin	37	42	41	29	27	25	28	22	24	40	32	24	24.8-29.6	26.6	1.54	0.445	5.7
Ht.at A.origin	27	29	28	23	21	20	22	17	18	28	24	19	19.0-20.7	19.9	1.01	0.291	5.0
Ht.at C.peduncle	12	12	12	9	9	8	10	8	7	11	10	7	7.3-9.3	8.3	0.53	0.153	6.3
Head length	37	38	37	29	30	27	31	24	23	40	33	24	25.0-28.9	26.9	1.59	0.459	5.9
Predorsal length	41	45	45	32	31	30	33	26	27	42	37	28	28.6-31.9	30.0	1.18	0.341	3.9
													In head length				
Eye diameter	10	10	10	9	7	7	8	6	7	10	8	7	23.3-31.0	26.9	2.51	0.725	9.3
Snout length	10	9	9	8	6	7	7	6	5	8	8	5	20.0-29.4	23.8	2.86	0.827	12.0*
Inter orb.space	10	11	10	9	8	8	9	6	8	10	9	8	25.0-34.7	28.9	2.94	0.849	10.2*
Upper jaw length	12	13	14	11	10	10	10	9	9	14	11	9	32.2-39.1	35.8	2.41	0.697	6.7
Lower jaw length	8	9	11	8	7	8	8	6	7	10	7	7	21.2-30.4	26.2	2.92	0.843	11.1*
Second D.spine	24	25	26	21	16	17	16	13	—	—	—	—	53.3-72.4	63.5	7.38	2.132	11.6*
Third D. spine	23	24	25	20	—	17	—	14	13	24	20	—	56.5-68.9	62.8	4.27	1.234	6.8
Second anal spine	15	17	18	15	13	13	14	11	13	17	15	13	43.2-56.5	47.5	4.37	1.263	9.2
Pectoral fin length	29	30	30	24	23	22	23	19	19	32	25	20	74.2-85.3	80.1	3.20	0.924	4.0
Caudal fin length	34	35	37	33	30	31	33	24	26	34	33	33	85.5-137.5	105.2	12.90	3.728	12.2*
													In eye dia meter				
Longest G.raker	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	5.0-8.3	6.2	1.49	0.430	24.0**
Sex	F	M	F	M	F	M	M	M	M	F	M	M	* Variable; ** Highly variable				
Localith	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA = Calcutta				

TABLE 4

Morphometric characters of *Johnius macropterus* (Bleeker)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	240	108	130	129	129	107	111	90	107,108		97	In Standard length				
Ht.at D.origin	37	31	40	40	38	33	32	27	34	32	30	27.7-31.7	30.0	1.10	0.317	3.6
Ht.at A.origin	28	26	28	29	29	26	25	20	26	22	23	20.4-24.3	22.6	1.24	0.358	5.4
Ht.at C.peduncle	13	10	13	13	12	13	11	9	11	10	10	9.2-10.5	10.0	0.52	0.150	5.2
Head length	36	28	38	37	36	30	29	24	28	32	24	24.7-29.6	27.4	1.53	0.442	5.5
Predorsal length	34	32	41	39	39	28	32	22	33	32	30	24.4-30.5	29.2	2.16	0.624	7.3
												In Head length				
Eye diameter	8	7	8	8	8	7	7	6	7	7	6	21.1-25.0	23.4	1.82	0.526	7.7
Snout length	8	6	11	8	9	7	6	6	7	8	6	20.0-28.9	23.9	2.35	0.679	9.8
Inter orb.space	11	10	12	12	11	9	9	8	9	11	9	30.6-35.7	32.5	2.31	0.668	7.1
Upper jaw length	12	10	13	12	13	11	11	8	10	11	10	32.4-37.9	34.9	1.74	0.502	5.0
Lower jaw length	8	7	9	8	8	6	10	6	7	10	7	20.0-31.2	24.5	3.14	0.907	12.8*
Second D. spine	17	15	18	19	20	—	17	13	—	15	—	46.8-62.0	52.9	5.05	1.459	9.5
Third D. spine	17	15	19	18	18	—	17	13	17	15	14	46.8-60.7	53.3	4.86	1.404	9.1
Pectoral fin	29	27	—	32	33	—	27	20	24	23	22	80.5-96.5	89.1	5.08	1.468	5.7
Second anal spine	12	10	13	12	12	11	12	10	10	12	10	33.3-41.4	36.8	3.22	0.930	8.7
Caudal fin length	28	23	28	26	27	24	26	20	23	25	24	70.3-100.0	81.8	7.77	2.245	9.5
												In eye diameter				
Longest G.raker	1	1	1	1	1	1	1	1	1	1	1	12.5-16.6	14.1	1.32	0.381	9.3
Sex Barbel	1	1	1	1	1	1	1	1	1	1	1	12.5-16.6	14.1	1.15	0.332	8.2
Locality	F	M	F	F	F	F	F	M	M	F	M	* Variable				
Locality	MMM	PBN	PBN	PBN	PBN	TTN	TTN	MMM	MMM	MMM	MMM	MMM = Mandapam; PBN = Pabnan TTN = Tuticorin.				

TABLE 5

Morphometric characters of Johnius belangerii (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Range (%)	Mean (%)	S.D	S.E	C.V. (%)
Standard length	155	113	140	79	162	112	111	116	119	147	118	132	103	107	In Standard length				
Ht.at D.origin	50	35	42	23	51	33	33	31	34	42	35	38	30	52	26.7-32.2	29.7	1.39	0.371	4.7
Ht.at A.origin	39	28	33	19	35	27	28	31	28	33	28	30	23	40	21.6-25.2	23.8	0.17	0.045	0.7
Ht.at C.peduncle	17	12	12	10	16	11	11	12	12	14	12	12	10	16	9.2-10.9	9.8	0.25	0.066	2.5
Head length	49	34	39	23	52	32	34	31	33	45	32	38	31	48	27.1-33.1	29.2	2.48	0.663	8.5
Predorsal length	53	31	41	25	53	35	30	34	34	47	33	41	32	51	27.0-34.2	30.2	2.08	0.556	6.9
															In head length				
Eye diameter	12	10	11	7	11	8	9	9	9	11	10	10	7	12	21.1-31.2	26.7	2.86	0.765	10.7*
Snout length	10	7	8	5	11	8	8	9	7	10	6	9	7	12	18.7-25.0	22.5	2.55	0.681	11.3*
Inter orb.space	12	8	10	6	13	8	7	9	9	10	9	10	7	11	20.6-28.6	24.9	2.37	0.634	9.5
Upper jaw length	17	12	14	8	18	11	11	13	11	16	12	15	11	16	30.0-41.9	35.4	2.85	0.762	3.0
Lower jaw length	12	8	11	5	13	7	7	9	8	9	8	11	7	11	20.0-28.9	24.3	2.78	0.743	11.4*
Second D.spine	26	20	23	14	26	20	17	16	20	24	21	24	17	27	50.0-65.6	57.1	5.00	1.337	8.7
Third D. spine	26	19	21	14	23	18	17	18	20	24	23	16	27	27	44.2-60.5	55.5	4.83	1.291	8.7
Second anal spine	19	14	15	16	13	13	15	13	14	14	14	16	15	19	38.7-49.0	42.5	2.86	0.764	8.7
Pectoral fin	30	23	25	15	31	20	22	24	23	26	21	25	20	35	59.6-77.4	65.9	1.47	0.393	2.2
Caudal fin	33	28	31	21	—	26	26	28	28	32	25	31	27	40	67.3-97.3	81.1	6.51	1.740	8.0
															In eye diameter				
Longest G.rake	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	4.2-7.1	5.2	0.27	0.073	5.2
Sex	F	F	F	-	F	F	F	F	F	M	F	M	F	F	* Variable				
Locality	PBN	CTA	CTA	KKN	PBN	PBN	CLT	CLT	PBN	PBN	CBN	CTA	CTA	CTA					

PBN = Pamban; KKN = Kakinada; CLT = Calicut; CTA = Calcutta

TABLE 6

Morphometric characters of Johnius carouna (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	124	122	106	147	98	114	125	147	150	83	128	151	138	In Standard length				
Ht.at D.origin	38	35	33	44	29	35	39	51	47	25	39	50	43	28.7-34.7	30.9	1.60	0.444	5.1
Ht.at A.origin	29	28	24	32	22	28	30	36	35	20	31	37	33	21.8-24.5	23.5	1.00	0.277	4.2
Ht.at C.peduncle	14	12	12	15	11	12	13	17	—	9	14	15	15	9.9-11.1	10.7	0.18	0.050	1.6
Head length	36	36	29	43	29	31	36	44	43	24	35	44	40	27.1-29.9	28.7	0.30	0.083	1.0
Predorsal length	41	39	33	46	28	30	40	50	47	27	40	48	44	28.5-33.1	31.8	1.88	0.522	5.9
														In head length				
To S.L%	6.4	7.3	6.6	6.1	7.1	7.0	7.2	7.4	6.6	8.4	7.0	5.9	7.2					
Eye diameter	8	9	7	9	7	8	9	11	10	7	9	9	10	20.4-29.2	24.3	2.18	0.605	8.9
Snout length	8	9	7	9	7	8	9	11	10	7	9	9	10	20.4-29.2	24.3	2.18	0.605	8.9
	8.8	8.1	7.5	7.4	8.1	8.4	8.0	8.1	8.0	8.4	7.8	7.9	7.9					
Inter orb.space	11	10	8	11	8	10	10	12	12	7	10	12	11	27.3-30.5	28.2	1.63	0.452	5.8
Upper jaw length	13	13	10	15	10	12	13	14	17	9	14	15	15	34.1-40.0	36.6	1.91	0.530	5.2
Lower jaw length	9	9	7	11	7	9	9	12	12	6	11	11	11	24.1-31.1	26.3	2.15	0.597	3.2
Second D.spine	18	19	19	-	15	-	21	22	23	16	-	26	23	50.0-66.6	56.0	5.67	1.575	10.1*
Third D.spine	—	—	17	—	15	—	20	22	22	—	—	24	22	50.0-58.6	53.8	2.94	0.816	5.4
To S.L%	11.3	11.4	13.2	10.2	12.2	12.2	11.2	10.8	10.0	14.4	10.9	10.5	11.5					
Second anal spine	14	14	14	15	12	14	14	16	15	12	14	16	16	34.0-50.0	43.3	3.31	0.919	8.2
Pectoral fin	20	20	18	24	15	20	20	26	24	12	21	25	22	55.7-64.5	56.7	3.94	1.094	6.9
Caudal fin	27	28	—	29	21	—	—	27	27	20	27	—	27	61.4-83.3	74.2	7.49	2.080	10.0
														In eye diameter				
Longest G.raker	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	4.5-7.1	6.2	2.6	0.072	4.1
Sex	F	M	F	M	M	F	F	F	F	M	F	F	F	* Variable				
Locality	CLT	CLT	CLT	CLT	CLT	CLT	PBN	PBN	MMM	MMM	MMM	KKN	MMM	CLT = Calicut; PBN = Pamban				
														MMM = Mandapam; KKN = Kakinada				

TABLE 7

Morphometric characters of <u>Johnius</u> <u>dussumieri</u> (Valenc

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Range (%)
Standard length	169	138	136	137	66	135	123	95	160	144	198	110	164	100	In
Ht.at D.origin	49	38	39	40	20	46	36	29	44	43	58	33	46	26	26.0-30.
Ht.at A.origin	36	29	27	31	16	29	30	23	35	34	42	25	35	20	19.8-24.
Ht.at C.peduncle	17	12	13	14	7	13	12	10	15	14	20	11	16	9	8.7-10.
Head length	55	42	45	45	21	42	36	31	50	45	65	34	52	33	29.3-33.
Predorsal length	45	47	46	45	21	47	37	33	50	48	65	34	53	35	30.1-35.
															In
Eye diameter	12	10	11	10	6	10	9	8	11	11	14	9	11	9	21.5-28.
Snout length	12	10	9	12	5	10	8	7	11	11	13	8	12	7	20.0-26.
Inter orb.space	15	12	13	13	6	13	12	9	14	14	19	10	15	10	27.3-33.
Upper jaw length	20	15	15	16	7	15	14	11	18	17	24	12	19	10	33.3-38.
Lower jaw length	15	11	12	10	6	13	12	7	13	11	17	8	12	8	22.2-28.
Second D.spine	34	31	35	35	16	27	31	25	28	30	38	26	31	24	56.0-86.
Third D. spine	33	29	33	33	16	27	28	22	28	30	38	26	30	24	56.0-77.
Second anal spine	14	14	12	13	6	13	13	10	14	11	15	11	12	11	23.0-36.
Pectoral fin length	39	39	31	30	14	30	30	22	36	37	46	28	38	24	66.6-82.
Caudal fin length	28	26	26	25	17	25	24	22	32	29	35	25	26	21	50.9-80.
															In
Longest gill raker	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	3.6-8.
Barbel length	2	4	4	4	1	3	3	2	5	3	6	3	5	2	16.6-45
Sex	F	F	M	F	F	F	F	M	M	F	M	F	F	F	* Varial
Locality	MMM	MMM	MMM	PBN	MMM	MMM	TTN	TTN	TTN	MDS	MDS	RMS	TTN	MMM	

MMM = Mandapam; PBN = Pamban; TTN = Tuticorin; MDS = Madras.

TABLE 8

Morphometric characters of _Johnius elongatus_ Mohan

(Measurements in mm)

	1	2	3	4	5	6	7	8	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	160	169	190	205	111	200	107	165	In standard length				
Ht.at D.origin	45	49	49	59	30	54	31	43	25.7-29.1	27.1	2.23	0.790	8.1
Ht.at A.origin	36	38	40	42	22	42	24	32	19.3-23.6	21.1	1.57	0.556	7.4
Ht.at C.peduncle	14	16	18	20	10	20	11	15	8.7-10.2	9.4	0.91	0.322	9.7
Predorsal length	50	50	53	65	34	64	33	51	27.8-32.0	30.5	2.62	0.929	8.6
Head length	40	49	51	60	32	63	34	48	25.0-32.7	28.8	1.99	0.705	6.9
									In head length				
Eye diameter	11	11	11	12	8	11	7	9	17.7-27.5	21.8	3.75	1.290	17.2**
Snout length	11	12	11	14	8	15	8	9	18.8-27.5	23.7	2.68	0.950	11.3*
Inter orb.length	13	13	15	17	8	16	9	14	25.8-32.5	28.0	2.99	1.039	10.4*
Upper jaw length	15	16	17	20	11	21	11	18	32.3-37.5	34.3	2.33	0.826	6.9
Lower jaw length	13	15	15	19	10	19	10	17	29.4-35.4	31.3	2.36	0.836	7.5
Second dorsal spine	25	25	31	--	16	32	21	25	50.0-62.5	55.6	5.68	2.014	10.2*
Third dorsal spine	28	24	30	35	15	32	20	23	46.0-58.8	53.0	5.19	1.840	9.8
Second anal spine	13	12	16	15	10	12	9	--	19.3-32.5	17.1	1.43	0.507	8.3
Pectoral fin length	34	32	37	43	21	42	21	34	61.7-77.5	69.0	1.84	0.652	2.6
Caudal fin	34	37	40	39	29	41	25	37	65.0-90.6	76.3	8.44	2.972	11.1*
Sex	F	F	M	F	M	M	F	F	* Variable; ** Highly variable				
Locality	VRL	VRL	VRL	VRL	VRL	VRL	MGL	BMY	VRL = Veraval; MGL = Mangalore				
CMFRI Reg.No.	188/1	/2	/3	/4	/5	187	188/6	/7	BMY = Bombay				

TABLE 9

Morphometric characters of <u>Johnieops vogleri</u> (Bleeker)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Range (%)	Mean (%)	S.D.	S.E.	C.V (%)
Standard length	142	129	150	157	102	175	148	134	132	96	101	143		In standard length			
Ht.at D.origin	44	40	46	51	33	54	45	45	46	30	32	44	30.4-34.8	31.9	1.47	0.425	4.6
Ht.at A.origin	31	32	35	37	24	40	35	32	33	22	23	31	21.8-25.0	23.4	0.30	0.087	1.2
Ht.at C.peduncle	14	14	16	16	10	18	16	13	15	10	11	13	9.7-11.3	10.4	0.19	0.054	1.8
Head length	44	42	47	48	33	60	45	45	43	30	32	43	31.0-34.3	32.0	1.25	0.361	3.9
Predorsal length	46	41	47	50	35	58	48	40	41	33	33	42	29.8-34.4	32.2	1.47	0.424	4.5
														In head length			
Eye diameter	10	10	11	10	8	13	10	11	10	8	8	10	21.6 -25.0	23.4	1.57	0.453	6.7
Snout length	8	10	11	10	8	13	10	11	10	7	8	11	18.1-25.6	23.0	1.99	0.575	8.7
Inter orb.space	13	12	13	15	9	17	12	13	13	8	9	12	26.6-31.2	28.4	1.42	0.410	5.0
Upper jaw length	22	10	20	22	15	24	20	19	17	14	15	20	39.5-46.9	44.1	2.62	0.757	5.9
Lower jaw length	17	14	14	16	11	19	15	15	14	10	11	15	29.8-34.8	32.7	1.69	0.488	5.1
Second D.spine	--	20	--	--	--	25	--	--	--	15	16	18	41.6-50.0	46.8	1.35	0.390	2.8
Third D. spine	19	20	--	22	16	25	22	20	19	16	17	19	41.6-53.3	46.8	3.79	1.095	8.0
Second anal spine	10	9	11	12	10	13	12	12	11	10	10	12	21.4-31.2	26.0	3.12	0.901	12.0*
Pectoral fin length	35	30	32	35	--	38	29	31	--	21	22	--	63.3-79.5	69.7	4.52	1.306	6.4
Caudal fin length	26	31	28	35	25	40	35	32	31	25	26	26	59.1-83.3	71.1	7.93	2.291	11.1*
														In eye diameter			
Longest gill raker	3	1	2	2	1	1	1.5	2	2	2	1	4	7.7-40.0	18.0	8.97	2.592	49.8**
Locality Sex	M	F	F	F	M	M	M	M	F	M	M	F	* Variable	** Highly variable			
Locality	MMM	MMM	MMM	MMM	KKN	KKN	KKN	MMM	MMM	CTA	CTA	PTM					

MMM = Mandapam; KKN = Kakinada; CTA = Calcutta; PTM = Puthalam.

[redacted]

TABLE 10

Morphometric characters of Johnieops ~~osseus~~ aneus ~~(Day)~~ (Bloch)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	136	112	108	122	116	124	134	121	99	122	95	105	133	142	In standard length				
Ht.at D.origin	45	39	34	41	38	42	42	48	33	38	32	33	42	42	29.6-34.8	32.3	1.43	0.382	4.4
Ht.at A.origin	31	28	25	32	29	30	31	28	25	28	24	25	32	31	21.8-26.2	24.0	1.24	0.332	5.1
Ht.at C.peduncle	13	12	11	13	12	13	13	13	11	12	10	11	14	14	9.5-11.1	10.3	0.16	0.042	1.5
Head length	41	36	44	35	36	42	44	38	33	39	31	34	42	45	28.7-33.3	31.8	1.38	0.369	4.3
Predorsal length	43	36	36	37	37	41	44	38	34	42	28	33	42	46	29.5-34.3	32.1	1.48	0.396	4.6
															In head length				
Eye diameter	10	9	8	8	8	10	10	10	8	9	7	8	9	10	22.2-26.3	23.5	1.59	0.425	6.7
Snout length	8	8	7	6	7	9	9	8	7	10	6	7	10	8	17.8-25.6	20.8	2.42	0.647	11.6*
Inter orb.space	13	10	11	12	12	13	14	12	11	12	9	11	13	15	27.6-34.3	31.7	1.86	0.497	5.8
Upper jaw length	18	15	14	15	15	18	19	15	13	15	13	15	17	19	38.2-44.1	41.4	2.00	0.534	4.8
Lower jaw length	14	10	9	11	12	13	15	12	10	14	11	12	13	14	26.4-35.9	32.0	2.73	0.729	8.5
Second D.spine	—	17	—	20	—	22	—	17	16	—	—	13	19	20	44.4-57.1	48.5	4.43	1.184	9.1
Third D.spine	21	—	17	19	18	22	22	17	—	17	15	18	20	23	43.6-54.3	50.0	3.16	0.844	6.3
Second A. spine	12	12	11	12	12	14	13	12	12	12	10	10	12	15	29.3-36.3	32.1	2.07	0.553	6.4
Pectoral fin length	37	29	29	33	—	37	35	33	—	32	25	29	32	36	76.2-90.2	84.1	5.02	1.352	5.9
Caudal fin length	31	27	26	29	27	34	34	27	27	28	25	27	25	34	71.8-82.8	72.4	3.43	0.917	4.4
															In eye diameter				
Length G.raker	2	2	2	2	1	1	1	1	1	1	1	2	2	1	11.1-25.0	16.5	3.62	0.967	21.9**
Sex	F	F	M	F	M	M	M	M	M	M	M	F	M	M	* Variable ** Highly variable				
Locality	MMM	KKN	NDR	KKN	KKN	CTA	MMM	MMM	MMM	MMM	PBN	PBN	PBN	PBN					

MMM = Mandpam; KKN = Kakinada; CTA = Calcutta; NDR = Neendakarai PBN = Pamban

TABLE 11

Morphometric characters of Johnieops sina (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	139	122	162	116	113	144	187	220	230	190	215	150	122	176	129	In Standard length				
Ht.at D.origin	43	37	51	35	36	48	57	75	41	58	71	48	37	57	40	30.2-34.1	31.6	1.20	0.310	3.8
Ht.at A.origin	31	28	39	26	28	35	43	50	31	44	53	33	28	42	28	21.7-24.7	23.2	1.00	0.258	4.3
Ht.at C.peduncle	13	12	17	11	12	16	20	23	13	19	21	15	12	19	11	8.5-11.1	10.0	0.06	0.015	0.6
Head length	41	40	52	34	37	43	59	72	42	62	76	51	40	59	38	29.4-35.3	32.0	1.84	0.474	5.7
Predorsal length	39	35	53	35	45	59	68	42	62	69	49	40	62	62	40	30.2-35.2	31.6	2.20	0.568	6.9
																In head length				
Eye diameter	11	9	11	9	9	10	15	15	10	14	17	11	10	13	9	20.5-26.8	23.1	2.19	0.565	9.4
Snout length	7	7	10	6	6	8	12	18	9	14	19	9	11	13	8	16.2-27.5	20.6	3.29	0.850	15.9**
Inter orb.space	13	11	14	10	11	13	17	21	11	17	21	14	11	15	12	25.4-31.7	28.3	1.76	0.454	6.2
Upper jaw length	20	18	23	16	17	21	25	30	18	25	30	21	18	25	20	39.5-50.0	43.8	3.35	0.865	7.6
Lower jaw length	15	14	20	13	13	15	18	25	15	20	28	18	14	19	15	30.5-39.5	35.5	2.46	0.636	6.9
Second D.spine	—	—	—	14	17	—	26	29	17	28	31	—	18	27	18	40.2-45.7	42.5	2.25	0.581	5.2
Third D. spine	18	16	—	15	—	—	29	31	19	28	34	18	18	26	18	35.3-49.1	43.0	3.36	0.868	7.8
Second A.spine	11	12	11	11	10	12	12	12	10	12	16	12	10	12	10	16.6-30.0	24.0	4.17	1.077	17.4**
Pectoral finlength	32	28	34	27	26	35	42	47	31	44	49	35	28	41	25	64.5-81.4	70.9	5.15	1.330	7.2
Caudal fin length	28	29	31	27	28	29	39	43	25	38	42	33	26	40	30	53.5-79.4	66.5	6.79	1.754	10.2*
																In eye diameter				
Longest G.raker	3	3	3	2	3	3	1	1	2	1	1	2	3	1	3	5.8-33.3	21.5	10.02	2.589	46.6**
Sex	F	F	F	F	F	F	M	F	F	F	M	F	F	F	M	* Variable; ** Highly variable				
Locality	MMM	MMM	MMM	MMM	MMM	MMM	MDS	MDS	MDS	MDS	MDS	KLR	KLR	WLR	CTA					

MMM = Mandapam; MDS = Madras; KLR = Kilakkarai; WLR = Waltair; CTA = Calcutta.

TABLE 12

Morphometric characters of *Johnieops dussumieri* (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	Range (%)	Mean (%)	S.D.	S.E.	C.V (%)
Standard length	115	126	117	125	127	98	111	132	In standard length				
Ht.at D.origin	35	38	37	37	31	31	34	42	29.6-32.3	31.0	1.14	0.404	3.7
Ht.at A.origin	26	30	29	28	30	23	25	33	22.6-25.0	23.5	0.31	0.109	1.3
Ht.at C.peduncle	12	12	13	13	13	11	12	14	9.5-11.2	10.5	0.16	0.056	1.5
Head length	40	40	40	42	41	30	33	39	29.5-34.8	32.1	1.85	0.659	5.8
Predorsal length	37	37	34	39	40	30	33	40	29.0-32.2	30.5	1.07	0.379	3.5
									In head length				
Eye diameter	8	9	8	7	8	7	7	10	16.6-25.6	21.1	2.64	0.936	12.5*
Snout length	8	8	9	9	8	7	6	8	18.2-23.3	20.7	1.57	0.556	7.6
Inter orb.length	12	12	12	13	14	10	10	13	30.0-34.1	31.8	1.78	0.631	5.5
Upper jaw length	16	17	16	17	19	14	15	18	40.0-46.6	43.4	2.98	1.056	6.8
Lower jaw length	12	12	13	13	15	10	12	16	30.0-41.0	33.8	3.65	1.294	10.8*
Second dorsal spine	17	17	--	20	20	15	17	16	41.0-51.5	46.3	4.73	1.677	10.2*
Third dorsal spine	18	17	15	19	22	16	17	21	37.5-53.8	47.8	5.74	2.035	12.0*
Second anal spine	11	12	13	10	10	11	10	12	23.9-36.6	28.5	3.72	1.319	13.0*
Pectoral fin length	26	32	24	26	30	22	23	36	60.0-92.3	71.9	9.88	3.503	13.7*
Caudal fin length	29	31	31	30	28	27	27	30	68.3-90.0	77.3	6.20	2.198	8.2
									In eye diameter				
Longest gill raker	2	2	2	2	2	2	2	2	20.0-28.5	25.3	7.22	2.560	28.5**
Sex	M	M	M	F	M	F	F	M	* Variable; ** Highly variable				
Locality	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN = Cochin.				

[redacted]

TABLE 13

Morphometric character of *Johnieops macrorhynus* Mohan
(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	107	168	143	175	136	151	131	118	100	100	163	162	158	152	143	131	134	126	156	168	In standard length				
Ht.at D.origin	28	46	37	50	40	42	46	32	26	28	49	45	47	45	38	37	38	37	36	49	25.8-30.1	28.1	1.37	0.306	4.9
Ht.at A.origin	21	35	30	35	29	32	27	24	21	22	37	34	34	31	29	27	29	27	34	31	18.1-22.7	20.8	1.07	0.239	5.1
Ht.at C.peduncle	10	17	14	17	14	15	13	12	10	10	16	16	16	14	13	12	12	13	15	15	8.9-10.3	9.7	0.49	0.109	5.1
Head length	33	52	42	55	43	47	40	35	29	30	48	44	46	45	43	41	38	38	46	51	27.1-31.6	29.9	1.14	0.255	3.8
Predorsal length	35	53	48	55	46	48	41	36	33	35	54	52	55	50	45	43	45	42	46	55	29.4-35.0	32.5	1.33	0.297	4.1
																					In head length				
Eye diameter	8	11	10	12	11	12	10	9	7	8	11	11	11	9	10	10	10	10	11	12	20.0-26.6	24.2	1.73	0.387	7.1
Snout length	8	13	10	14	10	12	10	10	7	8	12	10	11	12	10	11	10	10	11	12	20.0-28.6	24.6	0.74	0.165	3.0
Upper jaw length	12	18	15	20	16	17	14	12	10	10	16	17	17	16	15	15	13	14	17	19	33.3-37.2	35.7	1.39	0.311	3.9
Lower jaw length	8	13	11	14	12	12	10	9	7	7	11	14	15	12	13	11	10	12	13	16	24.1-31.3	27.4	2.64	0.590	9.6
Inter orb.space	8	13	10	13	11	12	8	9	7	7	12	11	12	11	11	10	11	10	13	12	22.5-28.9	24.8	1.54	0.345	6.2
Second D.spine	15	27	20	--	20	25	22	18	16	15	23	24	23	21	20	21	20	21	22	--	45.4-55.2	50.4	3.17	0.709	6.3
Third D.spine	16	22	21	--	20	23	22	17	16	14	23	23	23	21	21	--	20	19	21	--	45.6-55.1	49.8	0.88	0.196	1.7
Second A. spine	10	13	12	16	10	10	12	11	10	9	11	10	12	12	11	12	12	11	12	12	21.2-31.5	26.9	2.27	0.613	10.[illegible]
Pectoral fin	22	23	27	32	27	30	25	21	19	18	31	29	30	28	28	25	28	25	31	32	58.2-66.1	63.6	0.97	0.217	1.5
Caudal fin	24	33	27	32	29	31	--	23	23	20	31	33	35	35	33	29	33	--	33	35	58.2-86.5	70.6	6.53	0.118	9.2
																					In eye diameter				
Longest G.R.	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	4.1-7.1	5.3	0.80	0.188	15.0*
Sex	M	F	M	F	M	M	F	F	M	M	M	M	F	F	M	F	M	M	M	F	* Variable; MMM=Mandapam;				
Locality	MMM	MMM	MMM	MMM	MMM	MMM	CTA	CTA	CTA	CTA	WTA	VRL	VRL	VRL	VRL	BMY	BMY	BMY	BMY	BMY	CTA=Calcutta; WTR=Waltair;				
CMFRI Reg.No.	190/1	/2	/3	/4	/5	/6	/7	/8	/9	/10	/11	/12	/13	/14	/15	/16	/17	/18	189	190/19	BRL=Veraval; BMY=Bombay				

TABLE 14

Morphometric characters of <u>Kathala axillaris</u> (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	125	120	102	94	95	96	104	95	127	120	123	87	125	In standard length				
Ht.at D.origin	45	42	33	32	33	32	36	33	47	42	41	30	45	32.0-36.0	34.6	2.62	0.757	7.5
Ht.at A.origin	29	27	24	22	25	22	28	27	35	32	30	20	33	22.5-28.4	25.0	2.15	0.597	8.6
Ht.at C.peduncle	11	11	10	9	10	9	10	10	13	12	12	8	13	8.8-10.5	9.7	0.47	0.013	4.8
Head length	42	42	33	31	35	32	33	33	44	41	40	27	42	31.0-36.8	33.6	2.24	0.622	6.6
Predorsal length	39	39	31	24	32	30	39	28	40	33	37	29	41	25.5-37.5	31.3	9.22	2.561	29.4
															In head length			
Eye diameter	9	8	7	7	8	7	8	7	9	8	7	6	8	17.5-24.2	21.0	1.48	0.411	7.0
Snout length	9	9	7	7	6	7	6	5	9	7	9	6	9	15.5-22.2	20.2	2.37	0.658	11.7*
Inter orb-space	14	13	12	11	11	11	10	10	14	13	13	10	15	30.3-37.0	33.1	2.11	0.586	6.3
Upper jaw length	20	18	15	15	15	15	15	15	20	18	19	13	19	42.8-48.1	45.7	2.00	0.555	4.3
Lower jaw length	15	15	13	12	12	14	14	12	16	17	17	12	15	35.7-44.4	39.0	3.34	0.927	3.5
Second D.spine	--	15	10	10	10	--	10	11	11	13	11	11	12	24.0-40.7	31.3	4.09	1.136	13.0*
Third D.spine	--	15	12	13	12	15	14	14	18	16	15	12	14	33.3-44.4	39.6	4.05	1.125	10.2*
Second anal spine	15	14	12	13	12	14	12	14	15	14	14	10	15	33.3-43.7	36.9	3.35	0.930	9.0
Pectoral fin	35	33	28	25	--	25	--	28	37	32	35	22	36	78.1-87.5	82.4	3.37	0.936	4.0
Caudal fin length	23	23	22	23	22	21	24	23	25	25	--	20	--	54.8-74.2	64.8	7.01	1.948	10.8*
															In eye diameter			
Longest G.raker	5	6	5	5	5	5	6	5	5	5	5	4	4	55.5-75.0	68.0	6.72	1.866	9.8
Sex	M	F	M	F	M	F	F	F	M	F	M	M	M	* Variable				
Locality	CLL	CLT	CLT	CLT	CLT	CLT	KKN	KKN	VZM	VZM	VZM	MDS	NDI					

CLL=Colachel; CLT = Calicut; KKN = Kakinada; VZM = Vizhinjam; MDS = Madras; NDI=Neendakari

TABLE 15

Morphometric characters of *Macrospinosa cuja* (Hamilton)
(Measurements in mm)

	1	2	3	4	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	235	152	163	154	In standard length				
Height at dorsal origin	81	52	55	49	31.8–34.5	33.5	1.18	0.590	3.5
Height at anal origin	58	39	40	35	22.7–25.7	24.4	1.12	0.560	4.5
Height at caudal peduncle	21	14	14	13	8.4–9.2	8.8	0.81	0.405	9.2
Head length	70	47	50	46	29.8–30.9	30.3	0.49	0.245	1.6
Predorsal length	72	46	49	48	30.2–31.6	30.5	0.49	0.245	1.6
					In head length				
Eye diameter	13	10	11	10	18.6–22.0	20.9	1.47	0.735	7.0
Snout length	17	12	12	11	23.9–26.5	24.4	0.65	0.325	2.6
Upper jawlength	30	20	20	20	40.0–43.5	42.5	1.54	0.770	3.6
Lower jaw length	25	16	17	16	34.0–35.7	34.6	0.81	0.405	2.3
Second dorsal spine length	36	22	—	22	46.8–51.4	48.7	1.98	0.990	4.0
Third dorsal spine length	—	24	28	26	51.0–56.5	54.5	2.60	1.300	4.7
Second anal spine length	38	26	32	29	54.3–64.0	59.1	4.49	2.245	7.5
Pectoral fin length	52	35	36	34	69.4–74.4	72.5	1.97	0.985	2.7
Caudal fin length	51	38	40	35	72.8–80.8	77.4	3.33	1.665	4.3
Sex	M	F	M	F					
Locality	CTA	CTA	CTA	CTA	CTA = Calcutta.				

TABLE 16

Morphometric characters of Otolithoides biauritus (Cantor)

(Measurements in mm)

	1	2	3	4	5	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	303	246	200	253	850	In standard length				
Height at dorsal origin	66	51	41	51	92	20.1-21.8	20.7	0.05	0.022	0.2
Height at anal origin	43	33	27	31	61	12.2-14.2	13.4	0.63	0.282	4.7
Height at caudal peduncle	20	17	13	16	28	6.2-6.9	6.5	0.07	0.031	1.1
Head length	84	72	58	74	125	27.7-29.2	28.6	0.97	0.434	3.4
Predorsal length	90	75	62	75	130	28.9-31.0	29.9	0.73	0.327	3.4
						In head length				
Eyendiameter	12	10	9	10	15	12.0-15.5	13.8	1.21	0.542	8.7
Snout length	12	11	10	12	23	14.2-18.4	16.3	1.45	0.650	8.9
Interorbital space	22	19	16	17	30	22.9-27.6	25.4	1.77	0.793	6.9
Upper jaw length	39	30	26	31	50	40.0-46.4	42.9	2.39	1.071	5.5
Lower jaw length	26	23	20	23	38	30.4-34.5	31.8	1.45	0.650	4.5
Second dorsal spine	17	17	11	16	20	16.0-23.6	20.1	2.59	1.161	12.9*
Third dorsal spine	28	—	16	21	34	27.2-33.3	29.1	4.00	1.793	13.7*
Second anal spine length	13	11	10	10	24	13.5-19.2	16.2	1.99	0.892	12.3*
Pectoral fin length	63	47	41	49	89	65.3-75.0	69.7	3.60	1.614	5.1
Caudal fin length	65	50	39	51	79	63.2-77.4	69.2	4.63	2.076	6.6
						In eye diameter				
Longest gill raker	5	5	5	5	5	33.3-55.5	46.1	7.82	3.506	16.9**
Sex	M	M	F	M	M	* Variable; ** Highly variable				
Locality	BMY	BMY	CTA	CTA	MMM	BMY = Bombay; CTA = Calcutta; MMM = Mandapam.				

TABLE 17

Morphometric characters of <u>Otolithoides pama</u> (Hamilton)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	160	159	136	140	161	163	132	85	95	98	In standard length				
Ht.at.D.origin	40	40	33	37	40	38	34	25	25	26	23.3-30.2	26.1	2.06	0.652	7.9
Ht.at A.origin	22	23	19	21	24	24	20	14	13	13	13.7-16.5	14.7	0.80	0.253	5.4
Ht.at C.peduncle	12	12	10	11	13	12	11	7	7	7	7.3-8.3	7.7	0.43	0.136	5.6
Head length	46	49	41	43	49	49	41	29	30	29	28.7-34.1	31.1	1.67	0.528	5.3
Predorsal length	43	47	38	39	45	47	35	26	31	27	26.5-32.6	29.0	1.84	0.582	6.3
											In head length				
Eye diameter	6	6	5	6	6	5	6	3	3	3	10.0-14.1	11.9	1.62	0.512	13.6*
Snout length	8	10	9	8	10	9	7	7	6	6	17.4-24.1	19.9	2.08	0.658	10.4*
Inter orb.space	15	15	13	14	15	16	13	10	10	10	30.6-34.5	32.5	1.32	0.417	4.0
Upper jaw length	22	24	20	22	25	22	21	15	15	15	47.8-51.7	50.1	1.61	0.509	3.2
Lower jaw length	17	19	17	16	19	20	16	12	13	12	36.9-43.3	39.9	2.06	0.652	5.2
Second D. spine	15	18	15	16	21	18	16	10	11	13	32.6-44.8	37.7	3.46	1.094	9.1
Third D.spine	—	18	—	18	21	20	16	12	11	13	33.3-42.8	39.1	2.91	0.920	7.4
Second anal spine	7	7	5	7	7	7	7	5	6	6	12.2-20.7	16.1	2.54	0.803	15.7**
Pectoral fin length	42	41	37	42	46	46	34	25	27	26	82.9-97.7	89.9	4.25	1.344	4.7
Caudal fin length	44	38	38	44	45	49	34	29	31	26	77.5-103.3	93.8	8.05	2.547	8.6
											In eye diameter				
Longest gill raker	4	4	4	4	6	—	—	—	4	—	66.6-110.0	75.6	45.78	14.487	60.5**
Sex	F	M	F	M	M	F	F				* Variable; ** Highly variable				
Locality	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA	CTA = Calcutta				

TABLE 18

Morphometric character of *Panna microdon* (Bleeker)

(Measurements in mm)

	1	2	3	4	5	6	7	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	152	120	103	105	91	165	175	In standard length				
Ht.at D.origin	40	29	24	25	25	39	40	22.8-27.4	24.7	1.57	0.594	6.3
Ht.at A.origin	26	20	16	17	12	22	30	13.2-17.4	15.7	1.43	0.531	9.1
Ht.at C.peduncle	11	9	8	7	6	12	15	6.6-8.6	7.4	0.65	0.246	8.7
Head length	47	37	33	34	33	48	55	25.7-36.2	31.3	2.86	1.083	9.1
Predorsal length	46	39	34	33	33	46	54	30.3-36.2	31.9	2.13	0.806	6.6
								In head length				
Eye diameter	6	6	5	5	5	7	7	12.7-16.2	14.8	1.01	0.392	6.8
Snout length	12	8	7	8	8.	10	11	20.8-25.5	23.1	1.77	0.670	7.6
Inter orb.space	14	12	10	10	10	12	15	20.5-33.3	30.0	2.52	0.954	8.4
Upper jaw length	21	17	15	16	16	21	24	43.7-55.3	46.9	3.01	1.140	6.4
Lower jaw length	16	14	12	13	13	17	18	34.0-40.0	37.2	2.24	0.848	6.0
Second dorsal spine	15	--	8	9	9	12	--	24.2-31-9	26.9	2.76	1.045	10.3*
Third dorsal spine	16	--	14	10	13	18	--	29.4-42.4	36.5	5.50	2.083	15.1**
Second anal spine	11	8	8	8	--	10	11	20.8-24.4	23.0	1.46	0.553	6.3
Pectoral fin length	30	22	23	20	20	32	38	58.8-84.4	66.2	8.23	3.117	12.4*
Caudal fin length	27	30	27	26	27	37	37	57.4-82.2	76.8	2.61	0.988	3.4
								In eye diameter				
Longest gill rakers	4	4	3	3	3	--	5	57.1-66.6	61.7	4.02	1.522	6.5
Sex	M	F	F	M	M	F	M	* Variable;	** Highly variable			
Locality	CTA	CTA	CTA	CTA	CTA	PBM	PNKM	CTA=Calcutta; PBN=Pabman; PNKM = Panaikulam.				

TABLE 19

Morphometric and meristic characters of *Ehaba chaptis* (Hamilton)

	1	2	3
Standard length	158.0	105.0	113.0
Height	45.0	30.0	32.0
Head length	47.0	33.0	36.0
Eye diameter	12.0	9.0	9.5
Snout length	10.5	7.5	8.0
Upper jaw	19.5	13.5	15.0
Lower jaw	24.0	17.0	18.5
Pectoral fin	--	21.0	21.5
Second anal spine	21.5	15.5	18.0
Dorsal spine	X	X	X
Dorsal rays	25	24	24
Anal fin	II,7	II,7	II,7
Lateral line scales	52	52	51
Lateral transverse scales	10/20	10/20	10/20
Gill rakers	4/1/8	4/1/8	4/1/8

TABLE 20

Morphometric characters of <u>Pterotolithus maculatus</u> (Cuvier)

(Measurements in mm)

	1	2	3	4	5	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	231	145	146	107	107	In standard length				
Height at dorsal origin	53	33	32	25	25	21.9-23.3	22.8	1.08	0.484	4.7
Height at anal origin	39	26	23	19	20	15.7-18.6	17.3	1.15	0.515	6.6
Caudal peduncle	18	12	11	8	8	7.5-8.2	7.7	0.17	0.076	2.2
Head length	66	46	43	35	31	28.5-32.7	30.2	2.27	1.017	7.5
Predorsal length	75	46	47	36	34	31.7-33.6	32.3	0.70	0.313	2.3
						In head length				
Eye diameter	10	7	8	6	6	15.1-19.2	17.0	2.23	1.000	13.1*
Snout length	16	10	9	7	6	19.3-24.2	21.2	1.94	0.869	9.2
Interorbital space	14	10	10	7	7	20.0-23.2	21.7	1.43	0.641	6.6
Upper jaw length	28	20	20	15	14	42.4-46.5	44.0	2.42	1.085	5.5
Lower jaw length	25	17	17	12	13	34.2-41.9	38.0	3.34	1.497	8.8
Second dorsal spine	23	13	14	14	14	28.0-40.0	35.1	4.52	2.026	12.8*
Third dorsal spine	30	—	21	15	14	42.8-48.8	45.5	2.62	1.174	5.7
Second anal spine	13	7	10	6	6	15.2-23.2	18.0	3.19	1.430	16.9**
Pectoral fin length	44	26	27	20	20	57.1-66.1	61.4	4.82	2.161	7.8
Caudal fin length	42	31	35	28	27	63.6-87.0	75.8	9.26	4.141	12.2
						In eye diameter				
Longest gill rakers	1	1	1	1	1	10.0-18.3	14.6	3.52	1.578	24.1**
Lower canine	4	3	4	3	3	40.0-50.0	46.5	4.91	2.201	10.56*
Sex	F	M	M	F	M	~~40.0-50.0~~ * Variable ** Highly variable				
Locality	CTA	CTA	CTA	CTA	CTA	CTA = Calcutta.				

TABLE 21

Morphometric characters of Otolithes ruber (Schneider)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	183	181	184	162	200	179	210	127	154	172	190	170	174	169	111	In standard length				
Ht.at D.origin	42	39	39	39	45	40	49	26	31	38	40	38	38	37	29	20.1-26.0	22.1	1.50	0.387	6.7
Ht.at A.origin	31	30	29	25	33	32	36	21	26	31	33	30	31	29	21	15.4-18.9	17.0	0.85	0.219	5.9
Ht.at C.peduncle	15	15	15	13	16	17	19	12	14	17	16	15	16	15	10	8.0-9.8	8.7	0.85	0.220	9.7
Head length	58	56	57	50	64	56	66	41	50	55	58	51	54	53	38	29.5-34.2	31.4	0.34	0.087	1.1
Predorsal length	65	60	62	54	67	57	71	40	52	59	64	57	57	59	37	31.4-35.5	33.4	1.10	0.284	3.3
																In head length				
Eye diameter	10	10	10	10	11	10	11	8	9	9	11	10	10	10	7	15.6-20.0	17.7	1.05	0.271	5.9
Snout length	13	13	14	12	16	15	16	9	13	14	16	13	15	14	8	21.0-27.7	24.6	1.89	0.488	7.7
Inter orb.space	13	14	13	11	14	13	14	9	11	14	16	13	12	12	8	21.0-27.5	23.1	1.90	0.491	8.2
Upper jaw length	24	23	24	21	26	24	27	16	21	23	26	23	23	22	16	39.0-45.0	41.9	0.64	0.119	1.1
Lower jaw length	21	20	20	17	22	18	24	13	16	20	23	19	19	20	13	31.7-39.6	35.2	2.06	0.532	5.8
Second D.spine	25	24	26	20	21	20	22	15	—	21	25	23	—	24	16	32.3-45.6	40.2	4.33	1.118	10.8*
Third D. spine	27	27	28	23	25	23	27	16	—	23	29	26	25	23	15	39.0-50.8	44.5	4.24	1.095	9.5
Second A. spine	8	—	8	9	9	8	11	8	—	—	9	9	9	—	5	13.1-19.5	15.7	1.99	0.574	12.7*
Pectoral fin length	47	42	45	34	43	40	45	26	34	43	45	34	40	40	23	60.5-81.1	71.5	5.82	1.503	8.1
Caudal fin length	38	30	36	35	35	39	40	27	34	38	41	35	—	—	32	53.5-84.0	66.3	7.42	1.917	11.2*
																In eye diameter				
Longest G.raker	3	3	3	3	5	4	4	4	3	3	—	4	4	4	3	30.0-50.0	36.8	5.80	1.498	15.5**
Longest L.canine	4	5	4	4	5	—	5	3	5	5	—	5	4	4	2	28.5-55.5	44.3	7.29	1.883	16.4**
Sex	M	M	F	F	M	M	F	F	F	M	F	M	F	M	F					
Locality	MMM	MMM	MMM	KKN	KKN	KKN	PTR	NKI	CLT	CLT	CLT	WLR	WLR	WLR	CTA					

* Variable; ** Highly variable

MMM = Mandapam; KKN = Kakinada; PTR = Puthenthurai; CLT = Calicut; WLR = Waltair; CTA = Calcutta.

TABLE 22

Morphometric characters of Otolithes cuvieri (Trewavas)

(Measurements in mm)

	1	2	3	4	5	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	158	158	159	152	193	In standard length				
Height at dorsal origin	43	43	41	40	48	24.8-27.2	26.2	0.86	0.385	3.2
Height at anal origin	29	30	28	28	35	17.6-18.9	18.2	0.42	0.188	2.3
Height at caudal peduncle	14	14	14	14	17	8.8-9.2	8.9	0.19	0.085	4.1
Head length	52	53	53	54	62	32.1-35.5	33.4	1.07	0.479	3.2
Predorsal length	51	52	56	52	64	32.2-35.2	33.5	1.41	0.632	4.2
						In head length				
Eye diameter	11	12	12	11	13	20.3-22.6	21.5	0.93	0.417	4.3
Snout length	12	13	13	11	13	20.3-24.5	22.5	1.47	0.659	6.5
Interorbital space	14	13	13	12	16	22.2-26.9	24.7	1.55	0.695	6.3
Upper jaw length	22	24	24	21	25	38.8-45.2	42.3	2.57	1.152	6.0
Lower jaw length	19	20	20	18	21	33.3-37.7	35.8	1.89	0.847	5.3
Second dorsal spine	20	24	21	19	26	37.0-45.2	40.5	3.43	1.538	8.5
Third dorsal spine	20	25	23	17	28	21.4-45.1	41.1	5.65	2.533	13.7*
Second anal spine	8	10	7	7	9	12.8-18.8	14.9	2.13	0.955	14.3*
Pectoral fin length	35	39	37	39	43	67.3-73.8	70.4	2.18	0.977	3.1
Caudal fin length	35	40	37	40	46	69.8-74.2	72.1	2.87	1.286	3.9
						In eye diameter				
Longest gill raker	6	6	6	5	6	45.1-54.5	50.7	4.24	1.901	8.3
Lower canine length	3	3	3	2	3	18.1-27.2	24.5	3.84	1.717	15.6**
Sex	M	F	F	M	M	* Variable; ** Highly variable				
Locality	PBN	KLR	KLR	BMY	PTI	PBN = Pamban; KLR = Kilakarai; BMY = Bombay; PTI = Puthenthurai.				

TABLE 23

Morphometric characters of <u>Chrysochir aureus</u> (Richardson)

(Measurements in mm)

	1	2	3	4	5	6	7	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	231	202	132	141	103	171	200	In standard length				
Ht.at D.origin	63	49	33	37	26	43	51	24.2-27.3	25.5	0.89	0.337	3.5
Ht.at A.origin	43	40	25	28	30	35	31	18.6-20.5	19.6	0.70	0.265	3.6
Ht.at C.peduncle	23	20	13	14	10	18	21	9.7-10.5	10.0	0.01	0.003	0.1
Head length	76	63	43	49	33	57	64	31.2-33.3	32.6	1.80	0.681	5.5
Predorsal length	84	70	47	49	33	63	65	32.0-36.8	34.6	1.00	0.378	2.9
								In head length				
Eye diameter	12	11	9	9	7	10	11	15.8-21.2	18.3	1.87	0.708	10.2*
Snout length	16	14	11	9	9	13	13	18.3-27.2	22.5	2.48	0.939	11.0*
Inter orbital space	14	11	7	8	6	10	11	16.2-18.2	17.3	0.94	0.356	5.4
Upper jaw length	32	26	18	20	14	24	26	40.6-42.4	41.6	0.28	0.106	0.7
Lower jaw length	25	21	14	16	—	20	20	31.2-35.1	32.9	1.27	0.481	3.8
Second dorsal spine	21	24	14	20	13	24	20	27.6-42.1	35.9	5.11	1.935	14.2*
Third dorsal spine	30	28	19	23	15	26	26	39.5-46.9	43.8	2.56	0.969	5.8
Second anal spine	12	14	9	12	8	10	14	15.8-24.5	21.0	3.08	1.166	14.6*
Pectoral fin	57	52	34	40	28	41	43	67.2-82.5	77.4	5.91	2.238	7.6
Caudal fin	52	49	37	40	35	46	46	71.8-106.1	81.8	11.38	4.310	13.9*
								In eye diameter				
Longest gill raker	3	2	2	2	1	2	2	14.3-20.5	20.0	3.26	1.234	16.0*
Sex	F	F	M	M	M	M	M	* Variable character				
Locality	KKN	CTA	CTA	CTA	CTA	CTA	MDS	KKN = Kakinada CTA = Calcutta; MDS = Madras.				

[redacted]

TABLE 24

Morphometric characters of Pennahia macrophthalmus (Bleeker)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	180	134	208	173	133	156	150	123	174	185	132	150	153	138	210	In Standard length				
Ht.at D.origin	52	45	71	61	41	47	44	36	50	59	42	50	49	46	69	28.8-35.2	31.6	3.77	0.97	11.9*
Ht.at A.origin	39	32	49	44	29	31	31	25	35	42	28	35	32	31	47	19.8-23.8	21.7	2.47	0.63	11.3*
Ht.at C.peduncle	16	14	21	18	13	14	14	11	15	18	12	18	16	14	21	8.2-10.4	9.4	1.50	0.38	15.9**
Head length	61	47	69	62	45	54	54	38	57	62	35	57	51	48	70	30.5-36.0	33.8	2.81	0.72	8.3
Predorsal length	62	46	67	57	44	55	50	42	56	68	46	58	55	43	71	31.1-38.6	34.2	2.06	0.53	6.0
																In head length				
Eye diamete	13	11	17	15	11	11	12	10	12	13	11	13	13	12	16	21.0-25.4	23.4	2.42	0.62	10.3*
Snout length	15	12	15	15	11	13	11	10	13	15	12	15	14	12	17	21.7-27.7	24.5	2.71	0.70	11.0*
Inter orb.space	16	13	22	17	12	15	14	12	16	17	13	15	15	14	19	25.9-31.8	28.0	1.64	0.46	5.8
Upper jaw length	29	22	35	29	21	26	24	20	29	25	22	26	25	23	34	44.4-52.6	48.3	2.36	0.60	4.8
Lower law length	23	19	29	22	18	20	15	23	30	17	20	21	20	27	37	37.0-41.6	39.0	2.39	0.61	6.1
Second D.spine	--	20	--	26	16	--	22	17	23	22	16	--	22	21	32	35.4-45.7	40.5	4.43	1.14	10.9
Third D. spine	23	21	--	26	19	23	26	17	22	21	20	23	23	22	31	37.7-48.8	43.7	5.63	1.45	12.8*
Second anal spine	11	13	18	17	10	12	12	10	11	13	11	14	13	14	17	19.2-29.1	24.1	3.60	0.93	14.9*
Pectoral fin	46	35	60	48	35	39	36	30	44	42	35	40	38	35	52	66.6-76.9	74.5	5.59	1.44	7.5
Caudal fin length	33	30	38	35	26	30	33	21	32	34	26	31	33	29	38	54.3-64.7	57.1	3.57	0.92	6.2
																In eye diameter				
Longest G.raker	5	6	8	7	5	5	5	4	6	5	6	6	6	6	9	38.2-56.2	45.8	6.46	1.67	14.1*
Sex	M	M	F	M	F	M	M	F	F	F	F	F	F	M	F	*Variable ** Highly variable				
Locality	MDS	MDS	MDS	WTR	WTR	RMS	RMS	RMS	HGG	BMY	BMY	VRL	CTA	CTA	WTR					

MDS = Madras; WTR = Waltair; RMS = Rameswaram; BMY = Bombay; CTA = Calcutta;
VRL = Veraval; HGG = Hong Kong.

TABLE 25

Morphometric characters of *Atrobucca nibe* (Jordan & Thompson)

(Measurements in mm)

	1	2	3	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	143	91	111	In standard length				
Height at dorsal origin	—	26	31	27.9-28.6	28.2	0.62	0.352	2.19
Height at anal origin	31	20	24	21.6-22.0	21.7	0.41	0.236	1.88
Height at caudal peduncle	14	10	11	9.0-11.0	10.0	0.80	0.462	8.0
Head length	48	32	36	32.4-35.2	33.7	1.31	0.757	3.9
Predorsal length	46	31	34	30.6-34.1	33.2	1.48	0.855	4.4
				In head length				
Eye diameter	12	8	9	25.0	25.0	—	—	—
Snout length	10	7	9	20.8-25.0	22.5	1.85	1.069	8.2
Interorbital space	13	9	10	27.1-27.8	27.6	0.74	0.427	2.7
Upper Jaw length	23	15	17	46.9-47.9	47.3	0.22	0.127	0.4
Lower jaw length	19	15	14	38.9-46.9	41.7	3.65	2.109	8.7
Pectoral length	38	21	27	65.6-79.2	73.2	5.66	3.271	7.7
Second anal spine length	10	8	10	20.8-27.8	24.5	2.88	1.664	11.7*
Length of second dorsal spine	20	10	13	31.2-41.7	36.3	4.24	2.450	11.7*
Length of third dorsal spine	20	13	13	36.1-41.7	39.4	2.46	1.420	6.2
Caudal fin length	36	25	30	75.0-83.3	78.8	3.65	2.109	4.6
				In eye length				
Longest gill raker	5	4	4	41.6-44.4	45.1	1.12	0.647	2.5
Sex	F	M	M	* Variable				
Locality	CTA	CTA	CTA	CTA = Calcutta.				

TABLE 26

Morphometric characters of *Dendrophysa russelli* (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	128	120	132	111	104	97	89	75	128	117	86	74	In Standard length				
Ht.at D.origin	46	41	47	37	37	32	29	25	42	40	28	23	31.1-35.9	33.7	1.39	0.401	4.1
Ht.at A.origin	36	34	40	30	30	27	24	20	36	32	24	19	25.6-30.3	27.7	2.53	0.731	9.1
Ht.at C.peduncle	15	15	15	13	12	12	10	9	15	14	10	9	11.2-12.5	11.8	0.42	0.121	3.5
Head length	42	39	44	35	34	32	28	25	42	39	26	24	30.2-33.3	32.4	0.96	0.277	2.9
Predorsal length	38	38	43	32	33	28	27	26	40	38	29	24	28.8-33.7	31.0	1.66	0.448	5.3
													In head length				
Eye diameter	10	10	11	10	9	9	8	7	11	10	8	7	23.8-30.7	27.1	1.93	0.554	7.0
Snout length	7	8	11	6	6	5	6	6	8	8	6	6	16.6-25.0	20.4	3.23	0.933	15.8**
Inter orb.space	10	9	10	9	9	8	6	6	10	9	7	6	21.4-26.9	24.2	1.67	0.482	6.9
Upper jaw length	15	13	16	13	11	11	10	10	15	14	10	8	32.3-40.0	35.7	2.03	0.587	5.7
Lower jaw length	10	10	11	10	8	9	7	6	10	10	8	5	20.8-30.7	25.4	2.97	0.858	11.7*
Second D.spine	—	16	15	15	14	—	12	11	—	15	12	11	34.1-45.8	41.8	3.67	1.060	8.8
Third D.spine	20	—	—	19	15	13	12	12	10	15	14	11	38.4-54.3	46.1	5.18	1.497	11.2*
Second anal spine	17	20	17	17	16	16	14	13	18	17	15	11	38.6-57.7	47.3	5.24	1.514	11.1*
Pectoral fin	33	29	31	25	23	22	18	18	27	26	20	17	64.3-78.6	70.6	4.39	1.268	6.2
Caudal fin length	29	31	28	26	27	27	23	—	—	28	23	21	63.6-88.4	78.0	7.79	2.251	9.9
													In eye diameter				
Longest G.raker	1	1	1	.5	.5	.5	.5	.5	.5	.5	.5	.3	2.3-10.0	6.0	3.17	0.916	52.8**
Length of mental	8	8	-	7	6	7	7	-	-	-	5	-	62.5-80.0	74.9	8.21	2.372	10.7
Sex	F	M	M	F	F	F	F	M	M	F	F	M	*Variable;	** Highly variable			
Locality	MMM	MMM	MMM	MMM	MMM	MMM	MMM	MMM	CTA	MMM	MMM	MMM	MMM = Mandapam;	CTA = Calcutta			

TABLE 27

Morphometric characters of Nibea soldado (Lacepede)

(Measurements in mm)

	1	2	3	4	5	6	7	8	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	140	170	132	123	99	64	134	173	In standard length				
Ht.at D.origin	45	54	40	38	31	18	41	51	28.1-32.1	30.5	1.24	0.439	4.0
Ht.at A.origin	35	41	31	29	25	16	31	41	23.1-25.2	24.1	0.86	0.304	3.6
Ht.at C.peduncle	15	17	13	12	10	6	13	17	9.4-10.7	9.9	0.39	0.138	3.9
Head length	36	52	41	38	30	19	43	51	26.4-32.8	30.9	1.17	0.414	3.8
Predorsal length	42	48	43	37	32	21	39	51	29.1-32.8	30.6	1.95	0.691	6.4
									In Head length				
Eye diameter	10	10	9	9	8	5	10	12	19.2-26.6	23.3	2.28	0.808	9.5
Snout length	8	10	8	8	6	4	7	10	16.3-21.0	19.2	1.62	0.574	8.4
Inter orb. length	10	11	9	8	7	5	9	11	20.9-26.3	22.2	1.71	0.606	7.7
Upper jaw length	20	22	17	17	13	9	17	21	39.5-47.3	42.9	2.39	0.847	5.5
Lower jaw length	15	16	14	13	10	7	14	18	30.7-36.8	33.7	1.83	0.648	5.4
Second dorsal spine	20	28	22	17	15	10	21	25	43.4-53.8	48.5	3.64	1.290	7.5
Third dorsal spine	24	29	21	16	18	11	24	30	42.1-60.0	54.2	5.40	1.914	9.9
Second anal spine	22	28	22	20	18	9	20	27	46.5-60.0	51.8	4.46	1.581	8.6
Pectoral fin length	30	35	30	26	22	13	28	37	65.1-73.7	69.2	3.35	1.187	4.8
Caudal fin length	33	38	32	33	25	19	33	40	71.7-100.0	81.0	8.55	3.037	10.5*
									In eye diameter				
Longest gill rakers	3	4	3	4	3	1	3	4	30.0-50.0	37.3	6.38	2.262	17.1**
Sex	F	M	F	M	F	F	F	M	* Variable; ** Highly variable				
Locality	MMM	MMM	MMM	MMM	MMM	MMM	KLR	CTA	MMM = Mandapam; KLR = Kilakarai				
									CTA = Calcutta				

TABLE 28

Morphometric characters of Nibea albida (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	195	182	176	196	188	163	270	230	151	In standard length				
Height at D.origin	57	51	50	54	57	47	80	72	47	27.5-31.3	29.4	1.37	0.466	4.6
Ht. at A. origin	43	41	39	41	45	36	70	59	35	22.0-25.9	23.1	1.65	0.550	7.1
Ht. at C. peduncle	18	16	15	12	18	14	24	23	14	8.5-10.0	9.0	0.58	0.193	6.4
Head length	60	53	53	55	60	50	80	69	44	28.1-31.9	29.9	1.22	0.406	4.1
Predorsal length	63	60	55	63	57	52	79	76	50	29.2-33.1	31.2	2.99	0.996	9.4
										In head length				
Eye diameter	11	11	11	11	12	11	12	13	10	15.0-22.7	19.8	2.15	0.716	10.9*
Snout length	10	9	8	12	9	9	14	14	9	15.0-21.8	17.9	0.75	0.250	4.2
Interorbital space	13	1[illegible]	12	13	15	11	20	17	10	22.0-26.6	23.5	1.66	0.553	7.1
Upper jaw length	22	20	20	22	24	20	30	28	18	36.6-40.9	39.0	1.70	0.566	4.3
Lower jaw length	17	15	17	17	19	15	25	20	14	28.3-31.8	30.3	1.35	0.450	4.5
Second dorsal spine	26	27	25	26	25	26	38	33	22	41.6-52.0	47.4	3.14	1.046	6.6
Third dorsal spine	30	30	26	31	32	31	36	38	24	45.0-55.1	53.5	4.77	1.590	8.9
Second anal spine	27	26	25	28	29	26	38	32	23	45.0-52.3	48.7	4.42	0.806	4.9
Pectoral fin length	40	37	36	38	40	33	54	37	33	66.0-75.0	66.9	5.41	1.803	8.1
Caudal fin length	33	40	43	42	49	47	59	-	39	54.9-88.6	73.7	9.48	3.160	12.9*
										In eye diameter				
Longest gill rakers	3	3	4	3	2	2	-	2	2	15.4-36.4	24.6	7.87	2.623	32.0**
Sex	F	F	M	M	F	M	M	M	M	* Variable;		** Highly variable		
Locality	CTA	CTA	CTA	CTA	CTA	CTA	WTR	CTA	CTA	CTA = Calcutta;		WTR = Waltair.		

TABLE 29

Morphometric characters of *Nibea chui* (Trewavas)

(Measurements in mm)

Standard length	318
Height at dorsal origin	87
Height at anal origin	67
Height at caudal peduncle	26
Head length	99
Eye diameter	17
Snout length	24
Upper jaw length	40
Lower jaw length	31
Second dorsal spine	35
Third dorsal spine	47
Second anal spine	42
Pectoral fin length	73
Caudal fin length	73

TABLE 30

Morphometric characters of <u>Nibea semiluctuosa</u> (Cuvier)

(Measurements in mm)

	1	2	3	4	5	6	Range (%)	Mean (%)	S.D.	S.E.	C.V (%)
Standard length	240	178	170	168	179	272	In standard length				
Ht.at D.origin	74	60	55	52	58	85	30.8-33.7	32.1	1.35	0.553	4.2
Ht.at A. origin	57	42	40	42	42	66	23.5-24.2	23.8	2.06	0.844	8.6
Ht.at C.peduncle	23	17	16	17	17	28	9.4-10.2	9.7	0.31	0.127	3.2
Predorsal length	76	54	55	55	51	83	28.4-32.3	30.9	2.95	1.209	9.5
Head length	79	59	53	54	57	90	31.3-33.1	32.3	1.80	0.737	5.5
							In head length				
Snout	20	14	12	12	11	20	19.2-25.3	22.5	2.21	0.905	9.0
Eye diameter	15	12	10	11	11	15	16.6-20.3	19.0	1.05	0.430	5.5
Upper jaw length	29	21	21	20	23	34	36.7-40.3	37.8	1.08	0.442	2.8
Lower jaw length	25	20	17	16	21	32	29.6-36.8	33.2	2.65	1.086	7.9
Inter orbital space	16	13	13	11	14	21	20.2-24.5	22.4	1.86	0.762	8.3
Second dorsal spine	--	--	16	15	19	22	24.4-33.3	28.8	3.86	1.581	13.4*
Third dorsal spine	--	--	21	21	24	29	32.2-42.1	38.1	4.48	1.836	11.7*
Second anal spine	33	24	22	20	26	36	37.0-45.0	41.1	1.94	0.795	4.7
Pectoral fin length	47	39	32	33	35	49	54.4-66.1	60.4	3.97	1.627	6.6
Caudal fin	46	43	37	35	39	50	55.5-72.8	64.9	6.39	2.618	9.8
							In eye diameter				
Longest gill raker	--	2	2	2	2	2	13.3-18.1	17.2	2.33	0.954	13.5*
Sex	F	M	M	M	M	M	* Variable				
Locality	VRL	VRL	VRL	VRL	BMY	BMY	VRL = Veraval; BMY = Bombay				

TABLE 31

Morphometric characters of <u>Nibea</u> <u>diacanthus</u> (Lacepede)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	240	235	220	175	142	157	150	132	116	200	110	140	In Standard length				
Ht.at D.origin	70	66	69	52	42	45	41	40	33	59	33	40	27.3-30.3	28.8	1.13	0.326	3.9
Ht.at A.origin	55	53	47	35	30	36	32	30	23	43	22	25	17.8-22.9	21.2	1.52	0.439	7.2
Ht.at C.peduncle	23	21	19	16	12	15	14	12	10	18	29	12	8.2-5.6	8.9	0.47	0.136	5.3
Head length	78	77	71	58	47	48	48	43	37	63	37	46	31.5-33.6	32.4	1.05	0.303	3.2
Predorsal length	78	77	76	60	51	53	51	45	41	66	38	50	32.5-35.9	34.2	1.11	0.320	3.2
													In head length				
Eye diameter	13	13	12	11	9	10	9	9	8	12	8	10	16.6-21.7	19.3	1.94	0.560	10.0*
Snout length	13	13	13	14	9	9	11	8	8	13	8	10	16.6-22.9	19.7	2.01	0.580	10.2*
Inter orb. space	17	16	16	12	10	11	10	9	8	14	8	10	16.8-22.9	20.9	1.79	0.517	8.6
Upper jaw length	34	31	29	25	20	21	20	19	16	27	16	20	39.0-44.1	42.3	1.60	0.462	3.8
Lower jaw length	27	26	23	16	16	16	16	12	21	13	16	16	27.6-40.2	34.0	3.08	0.890	9.0
Second D. spine	30	28	22	--	17	20	17	16	14	24	10	16	27.0-41.6	35.8	3.66	1.057	10.2*
Third D. spine	36	--	28	23	21	24	20	20	16	29	14	21	39.0-50.0	43.3	3.87	1.118	8.9
Second anal spine	25	23	22	17	15	16	13	13	11	17	12	14	26.9-32.4	29.3	1.76	0.508	6.0
Pectoral fin	54	52	47	35	32	32	30	28	24	41	25	32	60.3-69.6	66.0	2.77	0.800	4.2
Caudal fin length	60	57	53	37	40	42	40	35	34	51	--	37	63.8-91.9	79.9	6.55	1.893	8.2
													In eye diameter				
Longest G.raker	2	3	2	2	2	2	2	2	2	2	2	2	15.4-25.0	20.5	3.12	0.902	15.2*
Sex	M	F	M	F	M	M	M	.	M	-	M	M	* Variable				
Localith	MMM	BMY	KKN	KKN	CTA	CTA	CTA	MMM CTA	KKN CTA	MM MMM	KKN	MMM					

MMM = Mandapam; KKN = Kakinada; CTA = Calcutta; BMY = Bombay

TABLE 32

Morphometric characters of <u>Nibea maculata</u> (Schneider)

(Measurements in mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Range (%)	Mean (%)	S.D.	S.E.	C.V. (%)
Standard length	195	175	196	151	163	105	92	132	162	158	124	111	In standard length				
Ht.at D.origin	66	55	62	49	52	33	30	42	50	50	37	34	29.8-33.8	31.7	1.12	0.323	3.5
Ht.at A.origin	45	43	46	39	39	25	22	30	38	36	27	27	21.7-25.8	23.6	1.04	0.300	4.4
Ht.at C.peduncle	19	18	19	15	16	10	10	13	15	15	11	11	8.8-10.8	9.8	0.51	0.147	0.5
Head length	68	60	69	53	30	33	46	54	54	43	35	28.	28.5-35.2	33.9	2.07	0.597	6.1
Predorsal length	63	59	66	50	58	35	32	47	55	54	41	36	32.3-35.6	33.8	1.23	0.355	3.6
													In head length				
Eye diameter	14	12	13	12	12	8	8	10	12	11	10	9	18.8-26.6	22.2	1.82	0.526	8.2
Snout length	15	14	18	11	14	10	11	11	13	13	11	8	22.0-33.3	25.3	3.82	1.104	15.1*
Inter orb.space	15	14	15	12	14	7	8	10	13	13	9	9	20.9-25.7	23.2	1.47	0.424	6.3
Upper jaw length	27	24	28	21	21	14	13	17	21	22	16	15	36.8-46.6	39.9	2.77	0.800	6.9
Lower jaw length	21	18	22	15	14	10	9	15	17	15	15	11	24.5-34.8	30.3	2.79	0.806	9.2
Second D.spine	—	21	22	19	20	13	11	17	—	18	15	15	33.3-43.3	36.2	3.65	1.054	10.0*
Third D. spine	22	26	—	20	23	14	13	20	—	—	17	17	32.3-46.6	41.2	4.49	1.297	10.9*
Second anal spine	18	18	18	16	16	12	10	15	16	16	13	14	26.1-40.0	31.1	4.24	1.225	13.6*
Pectoral fin	43	41	47	35	37	25	21	30	36	37	29	26	63.6-83.1	86.3	5.38	1.554	7.9
Caudal fin length	31	31	35	31	30	25	22	28	32	34	29	29	45.6-83.3	61.8	11.82	3.416	19.1**
													In eye diameter				
Longest G.raker	1.5	1.5	—	1.5	1	1	1	1	1	1	1	1	*8.3-12.5	10.4	1.50	0.433	14.4*
Sex	F	M	M	F	F	-	-	F	M	F	F	M	* Variable	** highly variable			
Locality	MNM	MNM	NPM	MNM	PTLM	MNM	TTN	MNM	MDS	MNM	MNM	PBM	PBM = Pamban				

MNM = Mandapam/ NPM = Nagpattinam; PTLM = Puthalam; TTN = Tuticorin; MDS = Madras

TABLE 33

Meristic characters of the species of *Johnius* and *Johneiops* and *Kathala*

Species	Dorsal rays												Ltr.(upper)							Ltr.(Lower)								
	23	24	25	26	27	28	29	30	31	32	33	34	4	5	6	7	8	9	10	9	10	11	12	13	14	15	16	17
Johhius carutta					7	16		1							1	5	17	1					1	19		3	2	
Johnius belengerii					1	3	11	4									6	12					1	11	4	2		
Johnius carouna				1	6	9	3							9	10					1	4	3	12					
Johnius glaucus						2	4	2							5	3							8					
Johnius coitor			3	4	5		1									10	3						3	9	1			
Johnius elongatus			1	1	2	1	3									1	7					3		3	2			
Johnius dusumieri	1	7	5	6												2	13	4							2	4	7	4
Johnius macropterus								1	6	2	2	1	1	11							11	1						
Johnius mannarensis					3											3					1	1	1					
Johnieops sina				1	4	10	6		1					1	13	8	1				13	5	5					
Johnieops volgeri				3	10	3	1		1							14	4				5	8	5					
Johnieops osseus			3	3	10	8	1	1						5	17	9						21	7	2	1			
Johnieops macrorhynus				2	7	5	6	1						3	7	9					9	7	3					
Johneops dussumieri			1	2	4	1	1							3	4	2					3	4	2					
Kathala axillaris				1	3	5	4										2	9	2			1	7	5				

[redacted]

TABLE 34

Meristic characters of the species <u>Nibea</u>, <u>Dendrophysa</u>, <u>Pennahia</u>, <u>Chrysochir</u> and <u>Atrobucca</u>

	Dorsal rays										Ltr.(upper)								Ltr(lower)											
	21	22	23	24	25	26	27	28	29	30	6	7	8	9	10	11	12	13	11	12	13	14	15	16	17	18	19	20	21	22
<u>Nibea maculatus</u>		1	1	10	3	1										8	3	1							1	5	4	5	1	
<u>Nibea diacanthus</u>			6	9	2									4	3	8	2						1	10	5					
<u>Nibea albida</u>			6	3									2	4	2	1				7		1	1							
<u>Nibea soldado</u>								1	6	2				3	5					1	5		2							
<u>Nibea semiluctuosa</u>								2	4								1	5									1	2	2	1
<u>Nibea chui</u>				1										1								1								
<u>Nibea bleekeri</u>						1	1							1	1											2				
<u>Dendrophysa russelli</u>					3	10	3	1				2	11	3					4	9	2									
<u>Pennahia macrophthalmus</u>	2	7	22	9	4	2					1	9	28	4	4				2	30	9	5								
<u>Chrysochir aureus</u>					1	4	2						6	1								1	4	2						
<u>Atrobucca nibe</u>							2	1					2		1				1			1								

TABLE 35

Meristic characters of the species *Otolithes*, *Bahaba* and *Macrospinosa*

	Dorsal rays													Ltr.(Upper)				Ltr (Lower)											
	20	21	22	23	24	25	26	27	28	29	30	31	32	8	9	10	11	11	12	13	14	15	16	17	18	19	20	21	22
Otolithes versicolor	1	1																											
Otolithes ruber								3	4	4	4	2		3	8	8			3		10	7	1						
Otolithes cuvieri											3	2		3	1	1			2	1	2								
Bahaba chaptis					2	1									2	1											3		
Macrospinosa cuja									3	1				2	1	1		2	2										

TABLE 36

Meristic characters of the species *Otolithoides*, *Panna* and *Pterotolithes*

	Dorsal rays															Ltr.(upper)							Ltr.(Lower)								
	28	29	30	31	32	33	34	35	36	40	41	42	43	44	45	12	13	14	15	18	19	20	13	14	15	16	17	19	20	21	22
Otolithoides biaurites	3	2																		2	2	1						1	4		
O. pama										1	2	2	2	2	1				10						1	1	2		6		
Panna microdon				1		2	2	2								1		3	3				1	2	3	1					
Pterotolithes maculatus			2	1	2													3	2											4	1

TABLE 37

Meristic characters of *Pennahia macrophthalmus* from various localities.

	Dorsal rays						Ltr.(upper)						Ltr.(lower)					Gill rakers(L)				
	21	22	23	24	25	26	6	7	8	9	10	11	11	12	13	14	15	9	10	11	12	13
Localities																						
Veraval				1					1						1					1		
Bombay		1	1	1				3						3					2	1		
Mandapam	2	13	30	7	1				38	15				13	40			1	45	7		
Madras			1	5	4	5	1	3	11				2	13					2	12	[illegible]	[illegible]
Kakinada				3	7	2		5	6	1				7	4	1			2	5	4	1
Waltair		1		2	5	1			7	2				8		1			3	6		
Calcutta				2	1				2	1				1	1	1				2	1	
Hong Kong		2	2	1	1				2		4				4	2		1	4	1		

TABLE 38

LIST OF SCIAENID FISHES KNOWN FROM INDIAN COASTS

No.	Name used in this work	Original name	Author & year
1.	Johnius carutta	Johnius carutta	Bloch, 1793
2.	Johnius belengerii	Corvina belengeri	Cuvier, 1830
3.	Johnius carouna	Corvina carouna	Cuvier, 1830
4.	Johnius glaucus	Sciaena glaucus	Day, 1876
5.	Johnius coitor	Bola coitor	Hamilton, 1822
6.	Johnius elongatus	Johnius elongatus	Mohan, 1975
7.	Johnius macropterus	Umbrina macropterus	Bleeker, 1853
8.	Johnius dussumieri	Umbrina dussumieri	Valenciennes, 1833
9.	Johnius mannarensis	Johnius mannarensis	Mohan, 1969.
10.	Johnieops macrorhynus	Johnieops macrorhynus	Mohan, 1975
11.	Johnieops dussumieri	Corvina dussumieri	Cuvier, 1830
12.	Johnieops ~~osseus~~ aneus	Sciaena osseus	Day, 1876
13.	Johnieops sina	Corvina sina	Cuvier, 1830
14.	Johnieops vogleri	Otolithes vogleri	Bleeker, 1853
15.	Kathala axillaris	Corvina axillaris	Cuvier, 1830
16.	Macrospinosa cuja	Bola cujas	Hamilton, 1822
17.	Otolithoides biaurites	Otolithes biaurites	Cantor, 1850
18.	Otolithoides pama	Bola pama	Hamilton, 1822
19.	Panna microdon	Otolithus microdon	Bleeker, 1850
20.	Bahaba chaptis	Bola chaptis	Hamilton, 1822
21.	Umbrina sinuata	Umbrina sinuata	Day, 1876
22.	Pterotolithes maculatus	Otolithes maculatus	Cuvier, 1830
23.	Otolithes cuvieri	Otolithes ruber	Trewavas, 1974
24.	Otolithes ruber	Otolithus argenteus	Schneider, 1801
25.	Otolithes versicolor	Otolithus versicolor	Cuvier, 1829
26.	Chrysochir aureus	Otolithus aureus	Richardson, 1846
27.	Dendrophysa russellii	Ombrina russelii	Cuvier, 1829
28.	Nibea soldado	Holocentrus soldado	Lacepede, 1802
29.	Nibea albida	Corvina albida	Cuvier, 1830
30.	Nibea bleekeri	Sciaena bleekeri	Day, 1879
31.	Nibea maculatus	Johnius maculatus	Schneider, 1801
32.	Nibea diacanthus	Lutianus diacanthus	Lacepede, 1892
33.	Nibea semiluctuosa	Corvina semiluctuosa	Cuvier, 1830.
34.	Nibea chui	Psuedosciaena coiber	Trewavas, 1971
35.	Argyrosomus hololepidotus	Labrus hololepidotus	Lacepede, 1802
36.	Pennahia macrophthalmus	Johnius aneus	Bleeker, 1850
37.	Atrobucca nibe	Sciaena nibe	Jordan & Thompson 1911.

II. FOOD AND FEEDING HABITS

1. Introduction:

The biological aspects of a fish are considerably influenced by the quantity of the food, for their growth changes have been associated with the changes in the quantity of the food (Cushing, 1968). Since growth of fish is directly influenced by such environmental factors as food, this field of study is important from the point of view of population changes. Apart from the relation of food and growth, there is close relationship between food, shoaling behaviour, migration and the condition of the fish.

Some of the important earlier Indian works on food and feeding habits of Indian fishes are those of Hornell and Nayudu (1924), Devanesan (1932), Job (1940) and Nair (1950, 1952). Later they were followed by Bhimachar and George, (1952), Sarojini (1954), Kuthalingam (1955), Prabhu (1955), Venkataraman (1956, 1960). Recently considerable work has been done on the food and feeding habits of fishes. The food and feeding habits of *Sardinella albella* were analysed by Bennet (1962) and Sekharan (1971); *Sardinella longiceps* by Dhulkhed (1964), Kagwade (1967) and Antony Raja (1969). Food of *Rastrelliger kanagurta* was analysed by Narayana Rao (1964) and that of *Coilia dussumieri* by Bal and Joshi (1956), of *Pampus argenteus*

argenteus by Kuthalingam (1967), Raconda russelliana by Varghese (1963) and Harpondon nehereus by Bapat (1970).

However, the food and feeding habits of sciaenid fishes had received much less attention. Venkataraman (1956) analysed the food of Otolithes ruber and Pseudosciaena sina from Calicut coast; Kuthalingam (1957) examined the food of Sciaena albida from Madras coast; Srinivasa Rao (1967) studied the food of Johnius aneus and J. coibor from Waltair coast; Rao (1968) observed that of Pseudosciaena diacanthus from Bombay coast; Rajan (1968) studied that of Pseudosciaena coibor from Chilka Lake and recently George et al (1971) studied that of Otolithus argenteus and Pseudosciaena sina of Cochin coast.

2. Material and methods:

3010 specimens were collected during 1968 and 1969 from the trawlers operating in Mandapam and Rameswaram. The specimens were preserved in 5% formalin in the field after opening the abdomen. Detailed examination of the stomachs was carried out in the laboratory with the aid of a binocular microscope.

Various methods such as volumetric method of Pearse (1915, 1916), points method of Hynes (1950), eye estimation and occurrence methods are in vougue for the study of food of fishes. Pillay (1952) critically reviewed the various methods used for the study of food of fishes and discussed the relative merits of each of them. According to Natarajan and Jhingran (1961) since the occurrence method or volumetric method alone would not five a good idea of food of fishes, an index was derived taking into account both occurrence and volume of food items. This method known as 'index of preponderance' appears to be more suitable for the study of food of carnivorous fishes.

Kuthalingam (1957) analysed the food of Sciaena albida by 'Pearse method', Venkataraman (1960) studied food of Otolithes ruber by volumetric method; Rao (1967) made use of points method in Johnius aneus and J. coibor; Venkatasubba Rao (1968) followed point occurrence method in Pseudosciaena diacanthus where as Rajan (1968) utilised volumetric method while studying food of Sciaena albida. Recently George et al (1971) studied the food of Otolithus argenteus and P. sina by volumetric and occurrence method.

In the present study volume and occurrence method was followed for the analysis of the food of the sciaenid fishes. The percentage of occurrence of different items of food in various months was determined by summing the total number of occurrence of all food items. From this the percentage of occurrence of each item was calculated. The volume of each food item was measured in a measuring cylinder which was graduated in 0.1 cc. The percentage of volume of each food item was determined from the total volume of all the stomach contents for the particular month. Then 'the index of preponderance' was calculated by using the formula

$$\frac{V \times O}{\Sigma VO} \times 100$$

where 'V' and 'O' were the percentage of volume and occurrence of food items respectively.

To study the condition of the stomachs or the feeding intensity in various months, the degree of fullness of the stomach was noted. Each stomach was assigned as 'gorged', 'full', '3/4 full', '1/2 full', '1/4 full', 'trace(and 'empty' depending on the quantity of the food in stomachs when more than 3.0 cc, 1.0 to 2.9 cc, 0.7 to 0.9 cc, 0.4 to 0.6 cc, 0.2 to 0.3 cc, less than 0.1 cc ~~xx~~ and no food was present in the stomach respectively. This method was followed since the degree of fullness determined by eye estimation alone without examining the stomach contents may be misleading as often empty stomachs appeared as 'gorged' or 'full'. From the total number of fishes examined in each month, the percentage of occurrence of the different categories of stomachs were determined. To find out the feeding variation in different size groups, the fishes were classified into 10 mm length groups and the food content of each length group was determined and then percentage of occurrence and volume were calculated sepatately.

The stomach contents were identified as far as possible upto the species level. Since the food items were often in an advanced state of digestion, the identification of them up to generic or specific level was not always possible. It may be mentioned that the term 'fishes' used in food analysis refers to different species of fishes which could not be identified owing to their advanced stage of digestion. Very often, only the parts of vertebral column were seen. The presence of mud when ever found is recorded in the stomach analysis, eventhough its occurrence is accidental.

3. Analysis of food of *P. macrophthalmus*

i. Quantitative and qualitative analysis.

'Fishes' formed the chief constituent of the stomach contents of *P. macrophthalmus* throughout the years 1968 and 1969 with a peak during February, March, May to July and September, 1968 and January, July and September, 1969. *Stolephorus commersoni* was observed in the stomachs throughout both the years except January and December during 1968 and September and November during 1969 with peaks in August and October in 1968 and February, June and August in 1969. *Acetes indicus* was another important food item observed throughout the year but for June 1968 with a peak in December. In 1969 also it was observed in all the months except May with peaks in March and October to December. Penaeid prawns formed the food of *P. macrophthalmus* throughout the year but for August 1968 and April 1969 with peaks during January 1968 and May, October and December in 1969. *Lucifer* sp. was another food item which occurred almost throughout both years. It was absent during January 1968 and May 1969. Isopods occurred in 'trace' quantities from March to August and October 1968 and during January May, July and September to November 1969. *Leiognathus* spp. were found to be in the stomach contents in small quantities during March, April, June, September and October, 1968 and March, April, October and November, 1969. *Sardinella* sp. occurred during April to August, 1968 with a peak in April. It was not observed durng 1969. *Anogon* sp. was observed in the stomach during June to August and December 1968 and was absent during 1969. *Sepia* sp. were found during January, March,to May, July, October and December, 1968 and January, February and April, 1969. Crabs occurred during February to May and October in 1968 and in March in 1969.

Apart from the above food items, Gobid fishes, sabellids, planarians, echiuroids, *Mysis* sp. nudibranchs, fish eggs, alpheids, *Calanus* sp. *Philene* sp., and fish larvae were found in the stomachs in small quantities.

ii. Seasonal variation in the food:

Though the stomach contents of *Pennahia macrophthalmus* consisted more or less of same organisms during 1968 and 1969, there were marked quantitative variation between months and years as shown in the Tables Nos. 39 - 60. Fisheres were the dominant food item during February, March, May to July and September durng 1968 and January, July and September in 1969. *S. commersoni* was found to be an important food item during May to October in 1968 with a peak in October while in 1969

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it formed an important food item during February, April to June and August with a peak in June and August. *Penaeus dobsoni* formed one of the major constituents of its food item during January to April with a peak in January during 1968 whereas in 1969 it was an important food item only during March, April and October to December with a peak in April. *Acetes indicus* was another important item which though occurred during all the months in both years except in May 1969, when it formed as a dominent food item only in December 1968 and March, October to December in 1969. *Lucifer* sp. occurred ~~of~~ as a food item of importance only during December in both the years. Isopods occurred in trace quantities during March to August and October in 1968 whereas in 1969 it occurred only in January, March, July and September to November. Crabs were encountered during February to May and October in 1968 and only in March during 1969. More fishes were found to feed on crabs during 1968 than in 1969. *Squilla* sp. were found in the stomach content during January to March and October in 1968 and only during December 1969. Here also more fishes were found to feed on *Squilla* sp. during 1968. *Sepia* sp. occurred in March to May, July, October and December in 1968 and in January, February and April in 1969.

Sardinella sp. *Apogon* sp. fish larvae, fish eggs, alphids, *Calanus* sp., amphipods, Philene sp. polychaete and planarians were found in the gut content only during 1968 whereas *Bregmaceros* sp. and *Mysis* sp. occurred only in 1969. These food items show distinct variation between both the years (Pl.IX, Fig.1,2).

The order of preference of food seemed to be more or less same atleast for the major constituents of food in both years. Among the food item 'fishes' *S. commersoni*, Penaeid prawns and *Acetes* sp. formed the first four major constituents during both years; fifth, sixth, seventh places were takenup by *Sardinella* sp. *Lucifer* sp. *Leiognathus* sp. in 1968 and by *Bregmaceros* sp., *Leiognathus* sp., and *Lucifer* sp. respectively during 1969. Other items occurred mostly in trace quantities and the order of importance is shown in the Tables 39-40.

iii. Food in relation to size.

P.macrophthamus was observed to take to carnivorous diet even from the 70 mm length. Fishes *S. commersoni*, penaeid prawns and the *Acetes indicus* formed the major food items from 80 mm to 199 mm. But fishes like *Leiognathus* spp., *Sardinella* sp. *Bregmaceros* sp. and gobids occurred in the stomachs of ~~XXXXX~~ fishes over 120 mm and 160 mm during 1968 and 1969 respectively. The bottom living mollusc like *Philine* sp. occurred in fishes of 150 mm length and above, and *Squilla* sp. in lengths above 130 mm. *Thallassema* sp. (*Echiuroid*) was observed in fishes of length above 100 mm whereas nudibranches occurred only above 140 mm and polychaetes in fishes exceeding 110 mm. However, it can be seen that though the size groups above 160 mm feed more on the bottom living animals pelagic forms (Stolephorus commersoni) formed the food of all length groups Table 66-67. As far as the major constitutents of the food were concerned there were less qualitative differences between the size groups (Pl.IX, Fig.3). The occurrence of mud in the stomach of larger fishes indicates that fishes of larger size groups feed at bottom also in addition to the column layer. Mud was not present in th stomachs of size groups below 100 mm. It may be stated that empty stomachs were observed in all size of the fishes groups (Pl.X, fig.1).

iv. Condition of feed

It was observed that empty stomachs predominated during January to March and July to October in 1968 and January to April and June to September in 1969. 'Trace' amount of food was found in the stomach during all the months with a peak in May 1968 and October 1969. '1/4 full' stomach were also observed during all the months during both the years whereas though '1/2 full' stomachs were found in all the months during 1968, they were found only during January to March, June to August, November and December 1969; '3/4 full' stomachs were found during all months except January and December in 1968 and September and November in 1969 (Table 41-42). It was further observed that 'full' stomach were seen throughout both years with a peak during July in 1968 and May during 1969. However, 'gorged' stomach occurred from April to December 1968 and January to March, July and September and November during 1969 with a peak in October 1969 and September 1969 (Pl.X, fig.2)

Many fishes show variaction in feeding intensity during spawning seasons. (Krishnamoorthy, 1971). Appa Rao (1967) observed increased feeding activity during post spawning period of *Pennahia macrophthalmus* from Waltair coast. In the present study though the empty stomachs were less during post-spawning period.

v. Food selection

In order to findout whether there was any preference of particular items of food in *Pennahia macrophthalmus* a record of other species caught along with *P. macrophthalmus* was maintained. It was found that though *Leiognathus* spp. was the dominant constituent of the fishery at Mandapam area contributing 90-95% of the catches it never formed as an important food item of *P. macrophthalmus*. Only larger size groups of *P. macrophthalmus* feed on them TO A SMALL EXTENT. Moreover *Stolephorus commersoni* which is one of the major constituents of the food items forms only a negligible part of the commercial catch. Hence it is quite possible that *S. commersoni* is preferred to other fishes. The occurrence of penaeid prawns, *Acetes indicus* and *Lucifer* sp. in the stomach was also another indication of its selection; probably the laterally compressed body form of the leiognathids with dorsal and anal spines may prevent *P. macrophthalmus* from feeding on them.

4. Food of other Sciaenids

i. *Johnieops sina*:

Johnieops sina occurred along with *P. macrophthamus* in the trawl catches. The food of 303 specimens were analysed by the index of preponderence method. It's food consisted mainly of 'fishes' (48.2%), followed by *Thallassema* sp. (17.3%), Penaeid prawns (15.1%), crabs (10.0%), and *Acetes indicus* (4.2%). Other items of its food were nudibranchs, *Gonodactylus* sp. *Lucifer* sp. *Squilla* sp. sebellids, *Sepia* sp. planarians and nerid worms. From its food items, it is evident that *J. sina* is a bottom feeder.

The condition of the stomach was also analysed. Empty stomachs were found to form 44.8%, followed by 'trace' stomach 26.3%, '1/4 full', 10.5%, '1/2 full', 5.6%, '3/4 full', 2.0%, 'full', 9.8% and 'gorged' stomachs 7.0%.

From the observations of the condition of the stomach it is quite evident that *J. sina* was better fed than that of *P. macrophthalmus*.

ii. *Johnius belengeri*:

The stomach content of this species were examined by volumetric method. The echiuroid worm, *Thallassema* sp. formed 26.6% of the food followed by *Acetes indicus* 26%, crabs 20% *Gonodactylus* sp. 13.3%, nudibranches 13.3%. From its food it could be seen that *J. belengeri* was a bottom feeder. The condition of stomach was found to be 'trace' 41.6%, '1/4 full' 25%, '1/2 full' 8.3%, 'full' 16.6% and 'gorged' 8.5%. It could be inferred that *J. belengeri* was observed to be also equally well fed as *J. sina*.

iii. *Johnius carouna*

Stomach content of *Johnius carouna* were also examined by volumetric method. It was found that the crabs formed 33.3% of food followed by *Gonodactylus* sp. 26.6%, echiuroids 6.6%, polychaete worms 6.6%, *Squilla* sp. 6.6%, *Octopus* sp. 6.6%, balanoglossids 6.6% and salps 6.6%. The condition of the stomach was, empty stomachs 27.7%, 'trace' 17.6%, '1/4 full' 38.8%, '3/4 full' 5.5%, and 'full' 11.2%. It was evident that *J. carouna* was also a bottom feeder.

5. Discussion:

Our knwoedge of food of demersal fishes is quite scanty when compared to that of pelagic fishes like oil sardines and mackerel. Kuthalingam (1957), Venkataraman (1960), Sawant (1964) Srinivasa Rao (1967), George et al (1971) and Suseelan and Nair (1972) has dealt on some aspects of the food and feeding habits of sciaenids.

While analysing the food of the sciaend fish *Sciaena albida* of Madras coast, Kuthalingam (1957) found that fishes formed the main bulk of food followed by *Acetes* sp. *Penaeus* sp. *Squilla* sp. and polychaetes; Venkataraman (1960) observed prawns, polychaetes, teleosts, amphipods and *Acetes* sp., in the gut contents of *Pseudosciaena sina* and prawns, polychaetes, *Squilla* sp., *Acetes* sp., amphipods and copepods in the gut contents of *Pseudosciaena belengeri* of inshore regions off Calicut; Srinivasa Rao (1967) found that fishes constituted the major item of food followed by penaeid prawns in food of *P. macrophthalmus* of Waltair coast. Though his observations were limited from January to April 1959 and between the size groups 18.2 to 24.0 cm, it may ~~be~~ indicate the food of *P. macrophthalmus* of Waltair coast. He also found crustaceans as a major constituent of food followed by fishes and anemones in *J. carutta*; Suseelan and Nair (1972) also observed teleost fishes, prawns, and *Acetes* sp., as the major food items of sciaenids of Bombay coast. The present study indicated that the 'fishes' prawns and *Acetes* sp., were the first three major component of the food items of *P. macrophthalmus* followed by *Lucifer* sp., *Isopods*, cephalapods and crabs. It could be inferred that *P. macrophthalmus* is a carnivorus fish inhabiting bottom and column layers.

While studying the condition of feed of *P. macrophthalmus* it was observed that empty stomachs dominated during the periods January to March and August to October in 1968 and in January to March and July to September in 1969. Similarly 'gorged' stomachs were also found from April to December in 1968 and January to March, July and September to November in 1969. From these observations it could be inferred that the feeding intensity is not influenced by the peak spawning season which was from March to April. Among the length groups also empty stomachs were observed more among the younger fishes of the length of 100 mm and below.

When the food of species in the two years were compared, some variations in food were observed between the years. Though fishes occupied the dominent constitutent of food, certain fishes like _Sardinella_ sp., _Apogon_ sp., and the bottom invertebrates like _Philene_ and planarians were observed only during 1968 where as fishes like _Bregmoceros_ sp., were found only during 1969.

Variations were observed in the food of juveniles and adult fishes. Bensam (1967) found that food of juveniles andadults of _Sardinella longiceps_ differred qualitatively. Similar observations were made by James (1967) in _Eupleurogrammus intermedius_ and _Lepturacanthus savala_. In the present study though no marked difference was observed between the food of juvenile and adult specimens, the larger fishes were found to feed more on bottom animals.

Generally feeding intensity of fishes is found to be influenced by maturation and spawning. Prabhu (1955) observed cessation of feeding in _Trichiurus haumela_ during the spawning season; Appa Rao (1967) and James (1967) also observed cessation of feeding in spawning and spent _P. macrophthalmus_ and _Lepturus savala_ respectively. But Kuthalingam (1957) and Kagwade (1971) found low rate of feeding during the peak breeding period of _Engraulis purava_ and _Caranx kalla_; Venkataraman (1960) observed ~~xxxxx~~ increased feeding activity during the maturing periods of many fishes off Calicut coast. However, James (op.cit.) found that sexual cycle did not influence the feeding intensity of E. intermedius. The present observations indicated that though there was no cessation of feeding during spawning season, the feeding intensity of P. macrophthalmus increased during post spawning period.

Selectivity of feeding is a common phenomena in fishes (Ivlev, 1961). It was observed that linear animals like S. commersoni, penaeid prawns etc. formed the major food of P. macrophthalmus where as laterally compressed fishes like leiognathids did not form its food though they occurred in large quantities along with it.

Food of other sciaenid fishes were also studied to have an idea of their food habits. It was found that Johnieops sina, Johnius belengeri and J. caruona are carnivorus fishes feeding on demersal fishes on bottom animals like echiuroids, crabs and prawns. Srinivasa Rao (op.cit.) and Suseelan and Nair (op.cit.) also made similar observations on the sciaenids of Waltair and Bombay coasts respectively.

TABLE 39

Food of <u>Pennahia macrophthalmus</u> for the year 1968 (Index of preponderance in %)

	Jan.	Feb.	Mar.	Aprl	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Rank
'Fishes'	14.09	73.69	63.30	23.99	75.46	50.19	51.89	19.28	76.59	20.32	--	19.94	489.34	1
S. commersoni	--	0.04	3.13	5.62	21.10	46.10	47.52	66.22	23.12	76.02	--	--	288.87	2
Sardinella sp.	--	--	--	51.13	1.30	2.96	0.09	12.46	--	--	--	--	67.94	5
Apogon sp.	--	--	--	--	--	0.02	0.40	0.21	--	--	--	2.24	3.87	8
Gobids	--	--	--	--	--	--	--	--	--	0.95	--	--	0.95	12
Leiognathus sp.	--	--	3.67	0.03	--	0.01	--	--	0.03	0.42	--	--	4.16	7
Fish larva	--	--	--	--	0.07	--	--	--	--	--	--	--	0.07	16
Fish eggs	--	--	--	--	--	--	--	--	0.06	--	--	--	0.06	17
Penaeid prawns	80.12	21.51	15.01	15.08	0.20	0.03	0.01	--	0.11	0.15	--	1.82	134.04	3
Acetes indicus	1.92	0.62	9.17	0.55	0.69	0.01	0.01	0.01	0.08	1.84	--	68.78	83.68	4
Lucifer sp	--	0.02	1.12	2.19	0.98	0.01	0.01	0.03	0.01	0.01	--	6.32	10.70	6
Squilla sp.	3.29	0.26	0.07	--	--	--	--	--	--	0.19	--	--	3. 81	9
Alphids	--	--	0.03	--	--	0.03	--	--	--	--	--	--	0.06	17
Calanus sp.	--	--	0.03	--	--	--	--	--	--	--	--	--	0.03	18
Isopod	--	--	0.03	0.01	0.03	0.03	0.01	0.08	--	0.01	--	--	0.20	13
Crabs	--	0.17	0.95	1.09	0.01	--	--	--	--	0.03	--	--	2.25	10
Amphipods	--	0.06	--	--	0.01	--	--	--	--	--	--	--	0.07	16
Nudibranch	--	0.06	0.05	--	--	--	--	--	--	--	--	--	0.11	14
Philine sp.	--	--	--	0.05	--	--	0.03	--	--	--	--	--	0.08	15
Sepia sp.	--	--	0.03	0.01	0.06	--	0.01	--	--	0.04	--	--	0.15	
Polychaetes	0.33	--	0.11	0.01	0.01	--	--	--	--	--	--	0.90	1.36	11
Echiuroids	--	--	--	--	--	--	0.01	--	--	--	--	--	0.01	20
Planarians	--	--	--	--	--	0.01	--	--	--	--	--	--	0.01	20
Semidigested matter	--	0.15	1.97	0.21	0.07	--	--	--	--	0.01	--	--	2.41	
Mud	0.33	3.42	1.33	0.03	0.01	--	0.01	0.71	---	0.03	--	--	5.87	

TABLE 40

Foof of Pennaha macrophthalmus for the year 1969 (Index of preponderence in %)

	Jan.	Feb.	Mar.	Apri	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Rank
'Fishes'	82.68	37.36	36.69	35.05	0.39	25.23	85.31	25.23	98.38	0.25	11.89	9.70	448.16	1
S. commersoni	1.64	45.38	5.30	28.57	37.95	74.33	14.16	74.33	—	0.86	—	5.26	287.78	2
Leiognathus sp.	—	—	0.09	9.75	—	—	—	—	—	9.56	0.48	—	19.88	6
Bregmaceros sp.	ZXE2	—	2.08	—	—	—	—	—	—	—	26.98	—	29.06	5
Penaeid prawns	2.62	11.97	24.84	—	61.66	0.01	0.04	0.02	0.25	56.06	24.42	47.90	230.79	3
Acetes indicus	11.34	0.29	30.55	15.58	—	0.29	0.30	0.29	0.13	28.08	32.46	28.78	148.09	4
Lucifer sp.	0.54	0.58	0.05	3.89	—	0.05	0.02	0.04	0.13	0.02	2.89	7.65	15.86	7
Squilla sp.	—	—	—	—	—	—	—	—	—	—	—	0.47	0.47	12
Mysis sp.	—	—	—	—	—	—	—	—	0.83	—	—	—	0.83	10
Isopods	0.21	—	0.19	—	—	—	0.02	—	0.13	0.12	0.09	—	0.76	11
Crabs	—	—	0.04	—	—	—	—	—	—	—	—	—	0.04	13
Nudibranchs	0.10	2.90	—	—	—	—	—	—	—	—	—	—	3.00	9
Sepia sp.	0.55	1.52	—	6.50	—	—	—	—	—	—	—	—	8.57	8
Schuiroids	—	—	0.02	—	—	—	—	—	—	—	—	—	0.02	14
Digested matter	—	—	0.09	—	—	0.02	0.02	0.02	0.13	3.93	0.75	0.24	5.20	
Mud	0.32	—	0.02	0.66	—	0.07	0.13	0.07	—	0.12	0.02	—	1.41	

TABLE 41

Condition of the stomach of <u>Pennahia macrophthalmus</u> during 1968 in the Palk Bay

Condition of stomach	Jan. (106)*	Feb. (197)	Mar. (236)	Apr. (127)	May (256)	June (247)	July (236)	Aug. (172)	Sept (159)	Oct. (159)	Nov. (Nil)	Dec. (28)
Empty stomach	77.3	70.0	60.1	46.5	30.4	37.4	52.5	67.2	77.4	68.5	-	32.1
.1 cc (Trace)	11.3	16.4	24.5	33.1	40.6	18.4	13.6	9.8	5.0	5.6	-	32.1
.2-3 cc (1/4 full)	6.6	7.6	5.9	7.4	14.4	22.6	10.1	6.3	6.9	5.7	-	17.9
.4-.6 cc(1/2 full)	3.9	3.0	4.2	3.2	5.4	9.9	9.3	6.4	1.9	3.8	-	10.7
.7-9 cc (3/4 full)	--	2.0	2.4	3.7	3.5	1.1	1.7	2.3	1.3	1.9	-	-
1.0-3.0 cc (full)	0.9	1.0	2.9	3.7	4.5	9.2	12.3	6.8	6.9	8.2	-	3.6
3.0 and above (gorging)	--	--	--	2.4	1.2	1.4	0.5	1.2	0.6	6.3	-	3.6
TED	100.00	100.0	100.0	100.0	100.0	10000	100.0	100.0	100.0	100.0		100.0

* Number of specimen examined within parenthesis.

TABLE 42

Condition of stomach of *Pennahia macrophthalmus* during 1969 in Palk Bay

Condition of stomach	Jan. (101)*	Feb. (67)	Mar. (103)	Apr. (20)	May (43)	June (86)	July (164)	Aug. (88)	Sep. (34)	Oct. (53)	Nov. (64)	Dec. (47)
Empty stomach	68.3	55.4	59.2	55.0	30.0	48.8	59.8	56.8	66.8	7.5	21.9	31.9
.1 cc (Trace)	12.8	5.9	14.6	20.0	20.0	17.4	11.6	25.0	21.1	69.8	46.9	49.0
.2-.3 cc (1/4 full)	10.0	14.9	6.8	10.0	10.0	9.3	11.0	7.9	6.1	13.2	23.4	12.8
.4-.6 cc (1/2 full)	2.0	8.9	3.9	--	--	8.2	4.3	4.6	--	--	3.1	2.1
.7-.9 cc (3/4 full)	2.0	5.9	3.9	5.0	10.0	3.5	3.0	2.3	--	3.8	--	2. 1
1.0-3.0 cc (full)	3.1	7.5	10.7	10.0	30.0	12.8	7.9	3.4	3.0	3.8	3.1	2.0
3.0 and above (gorged)	1.0	1.5	1.0	--	--	--	2.4	--	3.0	1.9	1.6	--
T o t a l	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Number of specimens examined within parenthesis.

TABLE 43

Food of *Pennahia macrophthalmus* for the month of January 1968

Food	%Vol.	Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	14.66	26.66	390.83	14.09	2
Acetes indicus	2.66	20.04	53.33	1.92	4
Penaeid prawns	66.66	33.32	2221.11	80.12	1
Squilla sp.	13.34	6.66	88.84	3.29	3
Polychaetes	1.34	6.66	8.92	0.33	4
Mud	1.34	6.66	8.92	0.33	
Total	100.00	100.00	2771.95	100.00	

TABLE 44

Food of *Pennahia macrophthalmus* for the month of February 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	57.69	33.82	1951.07	73.69	1
S. commersoni	0.86	1.16	0.99	0.04	8
Acetes indicus	1.70	9.67	16.44	0.62	3
Penaeid prawns	26.50	20.87	569.49	21.51	2
Lucifer sp.	0.43	1.01	0.43	0.02	9
Squilla sp	4.27	1.61	6.87	0.26	4
Crab	1.25	3.64	4.55	0.17	5
Amphipods	0.86	1.61	1.38	0.06	7
Nudibranchs	0.86	1.61	1.38	0.06	7
Semi Digested matter	0.86	4.81	4.13	0.15	6
Mud	4.72	19.20	90.81	3.42	-
Total	100.00	100.00	2647.54	100.00	

TABLE 45

Food of *Pennahia macrophthalmus* for the month of March 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	38.70	20.49	792.96	63.30	1
S. commersoni	16.00	2.45	39.20	3.13	5
Leiognathus sp.	14.00	3.29	46.06	3.67	4
Acetes indicus	5.84	19.69	114.96	9.17	3
Penaeid prawns	12.70	14.81	188.08	15.01	2
Lucifer sp.	1.70	8.19	13.92	1.12	6
Calanus sp.	0.40	0.81	0.32	0.03	11
Crabs	2.90	4.09	11.86	0.95	7
Alphids	0.42	0.81	0.34	0.03	11
Squilla sp.	1.10	0.81	0.89	0.07	9
Isopods	0.42	0.81	0.34	0.03	11
Polychaetes	0.80	1.64	1.31	0.11	8
Sepia sp.	0.42	0.81	0.34	0.03	11
Nudibranchs	0.40	1.64	0.65	0.05	10
Semidigested matter	2.50	9.83	24.57	1.97	
Mud	1.70	9.83	16.71	1.33	
Total	100.00	100.00	1252.51	100.00	

TABLE 46

Food of *Pennahia macrophthalmus* for the month of April, 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	12.70	20.30	257.81	23.99	2
S. commersoni	11.50	5.26	60.49	5.62	4
Sardinella sp.	60.90	9.02	549.31	51.13	1
Leiognathus sp.	0.43	0.77	0.33	0.03	9
Acetes indicus	0.86	6.77	5.82	0.55	7
Lucifer sp.	1.01	23.31	23.54	2.19	5
Penaeid prawns	8.66	18.70	161.94	15.08	3
Crabs	2.23	5.27	11.75	1.09	6
Isopods	0.14	0.77	0.11	0.01	10
Sebellids	0.14	0.77	0.11	0.01	10
Sepia sp.	0.14	0.77	0.11	0.01	10
Philini sp.	0.72	0.77	0.55	0.05	8
Semidigested matter	0.43	5.26	2.26	0.21	
Mud	0.14	2.26	0.01	0.03	
Total	100.00	100.00	1074.44	100.00	

TABLE 47

Food of *Pennahia macrophthalmus* for the month of May, 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	46.26	37.66	1742.15	75.46	1
S. commersoni	32.79	14.84	486.60	21.10	2
Sardinella sp.	14.40	2.11	30.38	1.30	3
Fish larva	0.47	3.49	1.64	0.07	7
Acetes indicus	1.36	11.79	16.03	0.69	5
Lucifer sp.	1.60	14.41	23.05	0.98	4
Penaeid prawns	0.97	4.80	4.65	0.20	6
Crab	0.01	0.87	0.01	0.01	11
Amphipods	0.06	0.10	0.06	0.01	11
Isopod	0.32	1.74	0.56	0.03	10
Sepia sp.	0.97	1.31	1.28	0.06	8
Polychaetes	0.32	0.33	0.10	0.01	11
Semidigested matter	0.32	5.24	1.67	0.07	
Mud	0.15	1.31	0.19	0.01	
Total	100.00	100.00	2308.37	100.00	

TABLE 48

Food of *Pennahia macrophthalmus* for the month of June 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	37.43	45.39	1698.94	50.79	1
S. commersoni	35.65	43.26	1542.22	46.10	2
Sardinella sp.	23.35	4.25	99.23	2.96	3
Apogon sp.	0.88	0.70	0.62	0.02	5
Leiognathus sp.	0.51	0.70	0.35	0.01	6
Acetes indicus	0.02	0.70	0.01	0.01	6
Lucifer sp.	0.13	2.10	0.27	0.01	6
Penaeid prawns	0.13	0.70	0.91	0.03	4
Gonodactylus sp.	1.39	0.70	0.97	0.03	4
Isopod	0.13	0.70	0.91	0.03	4
Planrians	0.38	0.70	0.26	0.01	6
Total	100.00	100.00	3344.69	100.00	

TABLE 49

Food of *Pennahia macrophthalmus* for the month of July 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	50.00	39.13	1956.50	51.89	1
S. commersoni	37.46	47.83	1791.71	47.52	2
Sardinella sp.	4.12	0.87	3.58	0.09	4
Apogon sp.	6.04	2.64	15.94	0.40	3
Penaeid prawns	0.01	1.17	0.01	0.01	6
Acetes indicus	0.01	2.60	0.02	0.01	6
Lucifer sp.	0.01	0.82	0.01	0.01	6
Isopod	0.01	0.82	0.01	0.01	6
Sepia sp.	0.64	0.82	0.56	0.01	6
Philine sp.	1.16	0.82	1.00	0.03	5
Thalàssemma sp.	0.53	0.82	0.46	0.01	6
Mud	0.01	1.74	0.02	0.01	6
Total	100.00	100.00	3769.82	100.00	

TABLE 50

Food of *Pennahia macrophthalmus* for the month of August 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	20.94	21.40	448.11	19.28	2
S. commersoni	34.47	44.64	1538.74	66.22	1
Sardinella sp.	34.47	8.40	289.54	12.46	3
Apogon sp.	7.84	3.54	27.99	1.21	4
Acetes indicus	0.12	1.78	0.21	0.01	7
Lucifer sp.	0.12	5.60	0.67	0.03	6
Isopod	0.52	3.90	2.03	0.08	5
Mud	1.52	10.71	16.27	0.71	
Total	100.00	100.00	2323.56	100.00	

TABLE 51

Food of *Pennahia macrophthalmus* for the month of September 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	77.34	38.29	2971.68	76.59	1
S. commersoni	19.13	46.87	896.62	23.12	2
Leiognathus sp.	0.63	2.12	1.33	0.03	6
Fish eggs	1.08	2.12	2.28	0.06	5
Acetes indicus	0.72	4.24	3.05	0.08	4
Penaeid prawns	1.08	4.24	4.57	0.11	3
Lucifer sp.	0.02	2.12	0.04	0.01	7
Total	100.00	100.00	3879.57	100.00	

TABLE 52

Food of *Pennahia macrophthalmus* for the month of October 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	17.65	27.14	479.02	20.32	2
S. commersoni	66.03	27.14	1792.05	76.02	1
Gobids	7.81	2.85	22.25	0.95	4
Leiognathus sp.	2.26	4.28	9.67	0.42	5
Penaeid prawns	0.65	5.72	3.71	0.15	7
Acetes indicus	2.15	20.00	43.00	1.84	3
Lucifer sp.	0.01	1.43	0.01	0.01	10
Isopod	0.13	1.43	0.19	0.01	10
Squilla sp.	1.61	2.86	4.60	0.17	6
Crabs	0.52	1.43	0.74	0.03	9
Sepia sp.	0.66	1.43	0.94	0.04	8
Semidigested matter	0.26	1.43	0.37	0.01	
Mud	0.26	2.86	0.74	0.03	
Total	100.00	100.00	2357.29	100.00	

TABLE 53

Food of *Pennahia macrophthalmus* for the month of December 1968

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	54.42	5.40	293.87	19.94	2
Apogon sp.	12.24	2.70	33.05	2.24	4
Penaeid prawns	4.97	5.40	26.83	1.82	5
Acetes indicus	23.45	43.24	101397	68.78	1
Lucifer sp.	2.46	37.86	93.13	6.32	3
Polychaetes	2.46	5.40	13.28	0.90	6
Total	100.00	100.00	1447.13	100.00	

TABLE 54

Food of *Pennahia macrophthalmus* for the month of January 1969

Food	%Vol.	%Occ.	VO	$\frac{VO\times100}{\Sigma VO}$	Rank
'Fishes'	70.72	26.76	1892.46	82.68	1
S. commersoni	8.42	4.44	37.38	1.64	4
Penaeid prawns	4.49	13.34	59.89	2.62	3
Acetes indicus	8.98	28.87	259.25	11.34	2
Lucifer sp.	1.12	11.11	12.44	0.54	6
Isopod	1.12	4.42	4.95	0.21	7
Sepia sp.	2.85	4.42	12.59	0.55	5
Nudibranchs	1.12	2.22	2.48	0.10	8
Mud	1.18	4.42	7.42	0.32	
Total	100.00	100.00	2288.86	100.00	

TABLE 55

Food of *Pennahia macrophthalmus* for the month of February 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	38.99	20.93	816.06	37.36	2
S. commersoni	26.60	37.26	991.11	45.38	1
Penaeid prawns	16.05	16.29	261.45	11.97	3
Acetes indicus	1.39	4.64	6.44	0.29	7
Lucifer sp.	1.83	6.94	12.70	0.58	6
Sepia sp.	6.89	4.64	31.97	1.52	5
Nudibranchs	6.25	9.30	64.07	2.90	4
Total	100.00	100.00	2183.89	100.00	

TABLE 56

Food of *Pennahia macrophthalmus* for the month of March 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	30.40	22.00	660.88	36.69	1
S. commersoni	15.92	6.00	95.52	5.30	4
Bregmaceros sp.	9.29	4.00	37.16	2.08	5
Leiognathus sp.	0.88	2.00	1.76	0.09	7
Penaeid prawns	24.91	18.00	448.38	24.84	3
Acetes indicus	15.28	35.00	550.08	30.55	2
Lucifer sp.	0.22	3.00	0.66	0.55	7
Crab	0.44	2.00	0.88	0.04	9
Isopods	1.76	2.00	3.52	0.19	6
Thallassema sp.	0.22	2.00	0.44	0.02	8
Semidigested matter	0.88	2.00	1.76	0.09	
Mud	0.26	2.00	0.44	0.02	
Total	100.00	100.00	1801.48	100.00	

TABLE 57

Food of *Pennahia macrophthalmus* for the month of April 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	18.36	23.08	423.74	35.05	1
S. commersoni	44.89	7.69	345.20	28.57	2
Leiognathus sp.	15.32	7.69	117.81	9.75	4
Acetes indicus	8.16	23.08	188.33	15.58	3
Lucifer sp.	2.04	23.08	47.08	3.89	6
Sepia sp.	10.20	7.69	78.59	6.50	5
Mud	1.03	7.69	7.92	0.66	
Total	100.00	100.00	1208.67	100.00	

TABLE 58

Food of *Pennahia macrophthalmus* for the month of May 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	0.99	16.66	16.49	0.39	3
S. commersoni	47.53	33.33	1584.17	37.95	2
Penaeid prawns	51.48	50.01	2574.51	61.66	1
Total	100.00	100.00	4175.17	100.00	

TABLE 59

Food of *Pennahia macrophthalmus* for the month of June 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	31.81	28.57	908.81	25.23	2
S. commersoni	66.16	40.47	2677.49	74.33	1
Acetes indicus	0.74	14.28	10.56	0.29	3
Lucifer sp.	0.37	4.76	1.76	0.05	4
Penaeid prawns	0.18	2.38	0.42	0.01	5
Semidigested matter	0.37	2.38	0.88	0.02	
Mud	0.37	7.16	2.64	0.07	
Total	100.00	100.00	3602.56	100.00	

TABLE 60

Food of Pennahia macrophthalmus for the month of July 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	66.72	53.62	3577.52	85.31	1
S. commersoni	29.29	20.28	594.00	14.16	2
Penaeid prawns	1.44	1.44	2.07	0.04	4
Acetes indicus	0.96	13.11	12.58	0.30	3
Lucifer sp.	0.10	1.44	0.14	0.02	5
Isopod	0.18	1.44	0.25	0.02	5
Semidigested matter	0.36	2.89	1.04	0.02	
Mud	0.95	5.78	5.49	0.13	
Total	100.00	100.00	4193.09	100.00	

TABLE 61

Food of *Pennahia macrophthalmus* for the month of August 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	31.81	28.57	908.81	25.23	2
S. commersoni	66.16	40.47	2677.49	74.33	1
Acetes indicus	0.74	14.28	10.56	0.29	3
Lucifer sp.	0.37	4.76	1.76	0.04	4
Penaeid prawns	0.18	2.38	0.42	0.02	5
Digested matter	0.37	2.38	0.87	0.02	
Mud	0.37	7.16	2.65	0.07	
Total	100.00	100.00	3602.55	100.00	

TABLE 62

Food of Pennahia macrophthalmus for the month of September 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	94.19	41.66	3923.95	98.38	1
Penaeid prawns	1.28	8.33	10.66	0.25	3
Acetes indicus	0.64	8.33	5.33	0.15	4
Mysis sp.	1.97	16.69	32.87	0.83	2
Lucifer sp.	0.64	8.33	5.33	0.13	4
Isopod	0.64	8.33	5.33	0.13	4
Semidigested matter	0.64	8.33	5.33	0.13	
Total	100.00	100.00	3988.80	100.00	

TABLE 63

Food of *Pennahia macropthalmus* for the month of October 1969

Food	%Vol	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	0.68	4.44	3.01	0.25	5
Leiognathus sp.	53.11	2.22	117.90	9.56	3
S. commersoni	4.79	2.22	10.63	0.86	4
Penaeid prawns	28.78	24.47	704.24	57.06	1
Acetes indicus	8.21	42.22	346.62	28.08	2
Lucifer sp.	0.34	0.34	0.11	0.02	7
Isopod	0.68	2.22	1.50	0.12	6
Semidigested matter	2.73	19.55	48.51	3.93	
Mud	0.68	2.22	1.50	0.12	
Total	100.00	100.00	124.02	100.00	

TABLE 64

Food of *Pennahia macrophthalmus* for the month of November 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	26.60	6.53	173.69	11.89	4
Bregmaceros sp.	28.48	13.84	394.16	26.98	2
Leiognathus sp.	4.58	1.53	7.00	0.48	6
Penaeid prawns	21.00	16.90	357.01	24.44	3
Acetes indicus	12.84	36.92	474.05	32.46	1
Lucifer sp.	4.58	9.20	42.13	2.89	5
Isopod	0.91	1.53	1.39	0.09	7
Semidigested matter	0.91	12.00	10.92	0.75	
Mud	0.10	1.53	0.15	0.02	
Total	100.00	100.00	1460.50	100.00	

TABLE 65

Food of Pennahia macrophthalmus for the month of December 1969

Food	%Vol.	%Occ.	VO	$\frac{VO \times 100}{\Sigma VO}$	Rank
'Fishes'	29.03	4.80	139.34	9.70	3
S. commersoni	15.94	4.76	75.87	5.26	5
Penaeid prawns	36.23	19.04	689.81	47.90	1
Acetes indicus	8.69	47.60	414.51	28.78	2
Lucifer sp.	5.79	19.04	110.24	7.65	4
Squilla sp.	2.88	2.38	6.85	0.47	6
Semidigested matter	1.44	2.38	3.42	0.24	
Total	100.00	100.00	1440.04	100.00	

TABLE 66

Percentage of occurrence and volume of food in different length groups of Pennahia macrophthalmus during 1968 from Palk Bay.

Length groups (mm)	'Fishes' O.	'Fishes' V.	S.commersoni O.	S.commersoni V.	Sardinella sp. O.	Sardinella sp. V.	Leiognathus sp. O.	Leiognathus sp. V.	Apogon sp. O.	Apogon sp. V.	Gobids O.	Gobids V.	Fish eggs O.	Fish eggs V.	A. indicus O.	A. indicus V.
70-79	57.1	35.7	28.6	57.3	-	-	-	-	-	-	-	-	-	-	14.4	7.2
80-89	51.9	34.1	25.9	53.5	--	-	-	-	-	-	-	-	-	-	7.4	1.8
90-99	45.4	26.0	4.5	11.5	-	-	4.5	15.2	-	-	-	-	-	-	13.7	13.3
100-109	23.1	38.2	34.6	32.3	-	-	-	-	-	-	-	-	-	-	-	-
110-119	30.9	32.2	22.6	45.7	-	-	-	-	-	-	-	-	-	-	10.1	2.0
120-129	29.1	40.2	21.9	40.0	0.8	2.1	-	-	-	-	-	-	-	-	14.1	3.1
130-139	35.7	25.3	20.7	60.7	1.9	3.7	0.5	3.7	0.5	0.5	0.5	0.8	-	-	12.5	1.4
140-149	44.6	47.5	15.0	36.1	3.7	6.3	0.5	0.8	-	-	0.5	2.5	-	-	10.6	1.8
150-159	31.7	31.0	18.0	20.2	6.0	21.3	1.5	1.3	2.2	8.0	0.7	4.1	0.5	0.5	11.7	0.8
160-169	41.8	35.3	26.9	29.7	7.5	26.3	1.5	0.2	-	-	-	-	-	-	2.9	0.2
170-179	25.0	7.9	19.4	11.3	8.3	55.8	5.5	3.9	5.5	7.1	-	-	-	-	11.1	0.3
180-189	37.5	18.6	-	-	18.7	78.8	-	-	-	-	-	-	-	-	6.2	0.5
190-199	50.0	77.3	16.7	3.6	-	-	16.7	18.2	-	-	-	-	-	-	-	-
200-209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

..Condt.

Penaeid prawns		Alphids		*Lucifer* sp.		*Squilla* sp.		Crabs		Isopods		Amphipods		Polychaetes		*Philene* sp	
O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.
7.0	8.0	14.3	7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.0	8.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.1	19.2	-	-	13.7	11.0	-	-	-	-	4.6	3.9	-	-	-	-	-	-
19.6	9.2	-	-	11.5	5.9	-	-	-	-	-	-	-	-	-	-	-	-
9.6	4.9	-	-	14.3	2.5	-	-	-	-	-	-	1.2	2.5	1.2	1.6	-	-
14.1	7.8	-	-	14.9	0.9	-	-	0.8	2.9	-	-	1.6	0.3	-	-	-	-
9.3	2.9	-	-	13.9	1.0	0.5	0.2	1.9	0.6	0.5	0.2	-	-	-	-	-	-
5.6	1.3	-	-	9.8	0.8	-	-	1.4	0.4	0.4	0.1	-	-	1.9	1.4	-	-
3.0	1.6	0.7	0.2	9.7	0.4	1.5	0.6	0.7	0.5	1.5	0.1	-	-	-	-	0.7	0.6
1.5	0.6	-	-	3.0	0.2	1.5	1.6	0.4	2.6	-	-	-	-	1.5	1.7	1.5	1.7
5.5	8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.5	1.4	-	-	6.2	0.1	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	16.7	0.9	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Contd.,

Sepia sp.		Nudibranchs		Echuroids		Semidigested matter		Mud		Empty stomach	No.fishes examined
O	V	O	V	O	V	O	V	O	V		
-	-	-	-	-	-	-	-	-	-	64.3	14
-	-	-	-	-	-	7.4	1.8	-	-	50.0	48
-	-	-	-	-	-	-	-	4.5	1.9	66.6	45
-	-	-	-	-	-	7.7	2.9	3.5	2.0	53.1	79
-	-	-	-	-	-	5.8	6.6	4.0	2.0	42.8	196
-	-	-	-	-	-	2.4	1.1	1.6	1.6	56.6	330
0.9	0.7	-	-	-	-	2.3	0.2	4.2	1.3	44.9	390
-	-	-	-	-	-	3.7	0.4	2.2	0.4	51.3	425
-	-	1.5	0.3	0.7	0.5	6.0	8.2	1.5	0.2	51.3	275
-	-	-	-	-	-	6.0	0.8	1.5	0.1	51.1	129
5.5	3.2	-	-	-	-	5.5	0.3	8.3	1.8	44.0	84
-	-	-	-	-	-	6.2	0.4	12.5	0.2	39.3	28
-	-	-	-	-	-	-	-	-	-	53.9	13
-	-	-	-	-	-	-	-	-	-	100.0	1

TABLE 67

Percentage of occurrence and volume of food in different length groups of *Pennahia macrophthalmus* during 1969 from Palk Bay

Length groups (mm)	'Fishes'		*S. commersoni*		*Leiognathus* sp.		*Bregmoceros* sp.		Penaeid prawns		*A. indicus*		*Lucifer* sp.	
	O	V	O	V	O	V	O	V	O	V	O	V	O	V
70-79	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80-89	25.0	14.3	-	-	-	-	-	-	25.0	42.8	25.0	28.6	-	-
90-99	10.0	20.0	10.0	26.6	-	-	-	-	10.0	13.3	50.0	26.7	20.0	13.3
100-109	14.3	54.5	14.3	22.7	-	-	-	-	7.1	4.7	-	-	35.7	9.1
110-119	41.4	66.7	13.8	17.2	-	-	-	-	10.4	9.2	17.3	3.4	3.4	0.6
120-129	16.2	38.4	8.8	30.8	-	-	-	-	10.3	14.3	35.3	9.0	13.2	3.0
130-139	31.9	31.1	12.7	38.0	-	-	-	-	14.9	24.5	21.3	3.4	6.4	0.3
140-149	20.9	31.5	22.4	50.3	-	-	-	-	13.4	8.5	20.9	4.5	8.9	1.8
150-159	36.9	64.1	10.9	15.1	-	-	-	-	16.0	8.7	15.2	4.9	6.5	0.2
160-169	29.4	30.5	17.6	28.8	3.9	27.4	-	-	11.8	9.5	19.6	1.7	7.8	0.7
170-179	19.2	56.1	11.5	10.0	3.8	3.5	-	-	23.1	23.5	23.1	2.6	7.7	0.4
180-189	50.0	91.3	10.0	3.0	10.0	1.6	10.0	2.0	-	-	-	-	-	-
190-199	50.0	94.1	-	-	-	-	-	-	-	-	-	-	-	-

Contd.,

[redacted]

Mysis sp.		*Sepia* sp.		Isopods		Nudibranchs		Echiuroids		Semidigested matter		Mud		Empty stomach (%)	No. fishes emam.
O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.	O.	V.		
-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	4
-	-	-	-	-	-	-	-	-	-	25.0	14.3	-	-	28.6	7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.8	13
14.3	4.5	-	-	-	-	-	-	7.1	2.2	7.1	2.3	-	-	58.6	29
3.4	0.6	-	-	3.4	0.6	-	-	3.4	0.5	3.4	1.2	-	-	42.0	88
1.4	0.7	1.4	0.7	5.9	1.5	-	-	-	-	2.4	0.8	5.9	0.7	33.7	98
4.2	0.6	-	-	4.3	1.5	-	-	-	-	4.3	0.6	-	-	33.9	126
-	-	-	-	3.0	0.4	1.5	2.2	-	-	3.0	0.2	6.0	0.6	52.5	160
--	-	2.6	1.1	-	-	2.2	2.5	-	-	3.9	2.3	5.4	1.0	50.3	167
-	-	-	-	1.9	0.2	2.2	0.7	-	-	3.9	0.3	2.2	0.2	37.6	101
-	-	3.8	2.2	-	-	3.8	0.9	-	-	-	-	3.8	0.8	51.0	49
-	-	-	-	10.0	1.8	-	-	-	-	-	-	10.0	0.3	58.8	17
-	-	-	-	-	-	-	-	-	-	-	-	50.0	5.9	0	4

LENGTH-WEIGHT RELATIONSHIPS

Introduction:

Length-weight relationships of fishes has been studied to establish mathematical relationships between length and weight and to measure the variations from the expected weight for length of individual fish or groups of fishes from different localities (Lecren, 1951). From this study, information on the fatness, general well being or the gonad development of the fishes can be obtained. In view of this practical utility the length-weight relationships of Pennahia macrophthalmus has been analysed for the years 1968 and 1969.

The length-weight relationship formula besides providing a means for calculating weight from length and a direct way of converting logarithmic growth rates calculated on length into growth rates for weight, may also indicate as maturity.

The length of fishes increases with weight showing that the weight of fish is a function of length. As length is a linear measure and the weight a measure of volume, the relation between length and weight can be expressed by the hypothetical cube law:

$$W = cL^3 \quad .. \quad .. \quad (6)$$

where 'W' is the weight of fish, 'L', its length and 'c' the constant. But Le Cren (1951) suggested that it is advisable to fit a general parabolic equation of the form

$$W = aL^n \quad .. \quad .. \quad (7)$$

where 'W' and 'L' are the weight and length, 'a' a constant equivalent to 'c' of the above equation (6) and 'n' a constant to be determined empirically from the data. This formula expresses the relation between weight and length better than the cubic formula. If the form and specific gravity remain constant, the formula could be used to calculate the weight of known length or *vice versa*.

If a fish does not change form or density, when it grows, the weight will be proportional to the cube of any linear dimension. But in reality the changes in morphology due to age, maturity and other ecological reasons often cause the coefficient or regression of logarithm of weight on logarithm of length to vary from 3.0. The value of the exponent 'n' in the parabolic equation usually lies between 2.5 and 4.0 (Hile, 1936; Martin, 1949). But 'n' may be found to be equal to 3 for an ideal fish which maintains constant shape (Allen, 1938). According to Beverton and Holt (1957) that significant departure from isometric growth (n = 3.0) are not usually common. However, Blackburn (1960) obtained low value of 'n' for the Australian barracouda, *Thyrsites atun*. Hence in *P. macrophthalmus* also it is considered better to fit this general equation.

The length-weight relationship can be expressed graphically by plotting the observed lengths and weights as a scattered diagram on double logrithmic graph paper. The fishes having the same length-weight relationship will lie on a straight line with some scatter due to individual variation. This line represents the logarithmatic form of equation:

$$\log W = \log a + n \log L \quad .. \quad .. \qquad (8)$$

where 'n' is the slope of the line and log 'a' its position. The fluctuations in the value of 'n' can be seen as changes in this slope. Though a line can be fitted by eye, an accurate line can be computed by regression method of least squares. Any one line can be fitted only to that range of size over which it is apparent that the fishes have the same length-weight relationship. The data from which the length-weight relationship is calculated should not have any selection for weight against length.

As it is noticed that the exponent 'n' is observed to vary for fishes from different localities, sizes and stages of maturity (Le Cren (1951), the data of length weight relationship of P. macrophthalmus is analysed separately for male and female immature (below 100 mm), maturing (100-120 mm) and mature (121-200 mm) fishes. The length groups are taken as criteria after establishing by analysis of covariance that within each group 'n' value is not significant at 5% level.

Material and methods:

Fishes were collected from trawl catches obtained by mechanised boats off Mandapam and Rameswaram. 246 males and 215 females were measured for the study of length-weight relationship. Total length and body weight were taken nearest to 1 mm and 0.1 gm respectively. Before weighing, water was blotted from the surface of body of fish.

Regression equations were derived for the length and weight of different size groups, sexes and years. Analysis of covariance was employed to test the significance at 5% level of probability.

Total lengths were plotted against standard lengths and the relationship was found to be linear. The regression formula

$$Y = a + bX \quad .. \qquad .. \qquad (9)$$

was fitted to the data. The equation was found to be $Y = -7.6447 + 0.88546\ X$. From the(Pl.XI, Fig.1-3) it can be observed that the data points are very close to the regression line indicating high degree of correlation between total length and standard length.

Length-weight relationships:

The following logarithmic equations were derived for different categories of fish s using the equation (8):

60 - 99 mm (1968 and 1969)		$\log W = -1.8282 + 1.9326 \log L$
100 - 120 mm (1968)	..	$\log W = -5.1105 + 3.5962 \log L$
100 - 120 mm (1968)	..	$\log W = -3.3672 + 2.7565 \log L$
121 - 200 mm (1968)	..	$\log W = -4.8618 + 3.4559 \log L$
121 - 200 mm (1969)	..	$\log W = -4.2914 + 3.3712 \log L$
Male (1968 and 1969)	..	$\log W = -4.7425 + 3.4070 \log L$
Female (1968 and 1969)	..	$\log W = -3.8440 + 3.2093 \log L$
1968 (male and female)	..	$\log W = -4.2810 + 3.1887 \log L$.
1969 (male and female)	..	$\log W = -4.0929 + 3.1106 \log L$

The equation for male was found to be:

$$W = 0.00001809 \; L^{3.4070}$$

and that for female

$$W = 0.0001432 \; L^{3.2093}$$

From the Tables 68-73 it can be seen that the variation between length-weight relationship of length groups is not significant, but the length-weight data of male and female were found to be significant at 5% level (Table 75). Length-weight relationship was shown in the Pl.XI, fig.1-3.

TABLE 68

Statistics for the regression of logarithm of weight of logarithm of length for the size groups 60 - 99 mm and 121 - 200 mm of *Pennahia macrophthalmus* for 1968 and 1969

	N	SX	SY	SXY	SX^2	SY^2
121 - 200	422	921.2155	1132.6716	2475.1885	2011.7844	3051.6043
60 - 99	26	50.4064	49.8814	96.8030	97.7737	96.0454

Sum of squares and products of linear regression of logarithm of length and weight

		Sum of squares and products				Errors of Estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F.
121 - 200	421	0.7939	11.4504	2.5946	3.2682	2.9708	420
60 - 99	25	0.0505	0.3472	0.0976	1.9326	0.1591	24

Analysis of covariance

Source of variation	D.F.	Sum of squares	Mean square	Observed F	5% F
Deviation from individual regression	444	3.1299	0.0704	1.19*	3.85-3.86
Difference between regressions	1	0.0843	0.0843		
Deviation from average individualregression	445	3.2142			

* Non significant at 5% level.

TABLE 69

Statistics for the regression of logarithm of weight on logarithm of length for the size groups 121 - 200 mm and 100 - 119 mm of Pennahia macrophthalmus for 1968 and 1969

	N	SX	SY	SXY	SX^2	SY^2
121 - 200	422	921.2155	1132.6716	2475.1885	2011.7844	3051.6043
100 - 119	84	171.2371	190.7223	391.1938	353.2006	433.5736

Sum of squares and products of linear regression of length and weight

		Sum of products				Errors of estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F.
121 - 200	421	0.7939	11.4504	2.5946	3.2682	2.9708	420
100 - 119	83	0.0385	0.5379	0.1289	3.3341	0.1063	82

Analysis of covariance

Source of variation	D.F.	Sum of squares	Mean square	Observed F
Deviation from individual regression	502	3.0771	0.0061	20.333*
Difference between regression	1	0.0003	0.0003	
Deviation from average individual regression	503	3.0774		

* Non-significant.

TABLE 70

Statistics for the regression of logarithm of weight of logarithm of length of male and female of *Pennahia macrophthalmus* for the years 1968 and 1969.

	N	SX	SY	SXY	SX^2	SY^2
Male	246	525.2620	623.2895	1335.8597	1123.0143	1596.8053
Female	285	616.4470	747.6542	1622.1574	1334.9162	1977.9405

Sum of squares and products of linear regression of length and weight

		Sum of squares and products				Errors of Estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F
Male	245	1.4690	17.5785	5.0049	3.4070	0.5268	244
Female	284	1.5587	16.3833	5.0024	3.2093	0.3289	283

Analysis of covariance

Source of variation	D.F.	Sum of squares	Mean square	Observed F	5% F
Deviation from individual regression	527	0.8557	0.0016	18.50*	3.85
Difference between regressions	1	0.0296	0.0296		
Deviation from average individual regression	528	0.8853			

* Significant at 5% level.

TABLE 71

Statistics for the regression of logarithm of weight on logarithm of length for the size groups 100 - 119 mm for the years 1968 and 1969

	N	SX	SY	SXY	SX^2	SY^2
1968	55	112.7694	124.4501	255.2637	231.2440	282.0194
1969	29	59.4677	66.2722	135.9301	121.9565	151.5542

Sum of squares and products of linear regressions of length and weight

		Sum of avuares and products				Errors of Estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F.
1968	54	0.0270	0.4225	0.0911	3.5963	0.0733	53
1969	28	0.0114	0.1058	0.0316	2.7719	0.0182	27

Analysis of covariance

Source of variation	D.F.	Sum of squares	Mean square	Observed F	5% F
Deviation from individual regression	80	0.0915	0.0011	4.74*	6.96
Difference between regressions	1	0.0054	0.0054		
Deviation from average individual regression	81	0.0969			

* Non significant at 5% level

TABLE 72

Statistics for the regression of logarithm of weight on logarithm of length of pooled data of *Pennahia macrophthalmus* for the year 1968 and 1969.

	N	SX	SY	SXY	SX^2	SY^2
1968	293	627.3118	746.8242	1604.8498	1344.9578	1924.8191
1969	240	518.5195	628.5650	1362.5257	1121.7109	1660.8718

Sum of squares and products of linear regressions of logarithm of length and weight

		Sum of squares and products.				Errors of Estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F.
1968	292	1.4830	21.2478	5.8768	3.1887	2.5084	291
1969	239	1.4506	14.6470	4.5123	3.1106	0.6108	238

Analysis of covariance

Source of variation	D.F.	Sum of squares	Mean square	Observed F	5% F
Deviation from individual regression with in years	529	3.1192	0.0059	1.18*	3.86-3.85
Difference between regressions	1	0.0050	0.0050		
Deviation from average regression	531	3.1242			

SX, SY = sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

D.F. = Degrees of Freedom; X^2, Y^2, XY = corrected sum of products and squares.

b = regression coefficient; SS = sum of square; * Non significant.

TABLE 73

Statistics for the regression of logarithm of weight on logarithm of length for the size groups 121 - 200 mm of Pennahia macrophthalmus for the year 1968 and 1969

	N	SX	SY	SXY	SX^2	SY^2
1968-1969	222	483.5147	591.6620	1289.9436	1053.4842	1583.6188
1969-1970	200	437.7008	451.0096	1185.2449	985.3002	1467.9855

Sum of squares and products of linear regressions of logarithm of length and weight

		Sum of squares and products.				Errors of Estimate	
	D.F.	Σx^2	Σy^2	Σxy	b	SS	D.F
1968-1969	221	0.3920	6.7572	1.3072	3.3347	2.3952	220
1969-1970	199	0.3903	4.5256	1.2432	3.1852	0.5687	198

Analysis of variance

Source of variation	D.F.	Sum of squares	Mean square	Observed F	5% F
Deviation from individual regression	418	2.9639	0.0071	1.61*	3.85-3.86
Difference between regressions	1	0.0044	0.0044		
Deviation from average individual regression	419	2.9683			

* Non-insignificant.

IV. CONDITION FACTOR

The length-weight relationship was analysed with a view to findout the variation from the expected weight for length of fishes. Individual variation from the general length-weight relationship was considered important than the length-weight relationship itself and had been frequently studied under the general term 'condition' (LeCren, 1951). This condition or the general well being could be found out by analysing the length-weight relationship. The specific gravity of fish might not be unity as Tester (1940) had shown in the herring *Clupea pallasi*. Kestevan (1947) discussed the importance of specific gravity in the study of 'condition'. But in most fishes the density is maintained the same as that of surrounding water by the gas bladder and the changes in weight for length may be due to changes in form or volume and not due to specific gravity.

Such changes in condition were analysed by means of a 'condition factor' (or coefficient of condition, or ponderal index (Thompson, 1942; Hile, 1936) which is given by the formula:

$$K = \frac{100\,W}{L^3} \quad .. \quad .. \quad .. \quad (10)$$

where 'K', is the condition factor, 'W', the weight (gm) and 'L', the length (mm) of the fish. The formula was based on the comparison of an ideal fish where $W \propto L^3$.

The value of 'K' may be affected by many factors which fall into three main categories.

1. The factors correlated with length as fishes may not obey the cube law in its length-weight relationship. The 'condition factor' varies with length according to the expression $K \propto L^{n-3}$. Thus except in rare instances where 'n' = 3, the condition factor of fish of different lengths cannot vary due to factors other than length. Other factors which will affect 'k' through 'n' is racial difference which is a genotypic factor.

2. Values of 'K' may be affected by selection in sampling.

3. Long term factors such as environment, food, parasitisation, maturity etc. may also affect the 'condition factor' through growth rate and average size.

It is possible to eliminate the effect of length, and correlated factors on 'K' by calculating a 'condition factor' which may be called 'relative condition factor' or 'Kn' that can be calculated by the formula:

$$K_n = \frac{W}{al^n} \quad .. \quad .. \quad (11)$$

where 'W' the weight, 'a' the constant and 'n' an exponent usually lying between 2.5 and 4.0

The length-weight relationship can be calculated by the logarithmic formula (Log W = log a+n log L) and mean weight W, for each length group can be computed from this log formula. The 'relative condition factor' can then be calculated from the formula:

$$K_n = \frac{W}{\hat{W}} \quad .. \quad .. \quad (12)$$

where 'W' is the observed weight, and '$\hat{W}$', the calculated weight.

The difference between 'K_n' and 'K' is that the 'K_n' measures the deviation of an individual from the average weight for length, while 'K' measures the deviation from a hypothetical ideal fish. Moreoverfrom the 'relative condition factor' it is possible to distinguish and measure the influence on condition of length and other factors whereas they are not separated in the 'condition factor'.

As the aim of this study was to trace the condition cycle of the fish through the year and in two successive years in relation to maturity and feeding habits, the data was divided into immature (below 120 mm) and mature fishes (above 120 mm). The 'relative condition factor', 'K_n' was obtained for each fish by using the formula $W = A + B\overline{L}$ and then dividing the observed weight (W) by the calculated weight ($\hat{W}$). The geometric mean of the 'condition factor','K_n', for monthly samples of P. ~~mm~~ macrophthalmus were calculated separately and are present in the (Table 74-75).

Thompson (1942) stated that the high and low 'condition' in Pleuronectes platessa were found before and after spawning. Hickling (1945) found that in Sardina pilchardus the 'condition' was low during prespawning period and high in post spawning period and thought that the variations were due to sexual cycle and the availability of food. Qasim (1957) observed that the low and high 'condition' might be due to general building up and loss of reserves respectively. Narasimham (1970) found in _Trichiurus lepturus_ an abrupt fall in 'K_n' value at a particular length at which 90% of the fishes were mature though he stated that the sexual cycle did not seem to influence the 'K_n' value to any perceptible degree. Marichamy (1970) also did not find consistent correlation between 'K_n' and feeding intensity in _Thrissina baelama_. However a steep fall in 'K_n' with onset of spawning was observed in _Nemipterus japonicus_ by Krishnamoorthy (1971) whereas James (1967) and Thomas (1969) could not find ~~and~~ any correlation between 'K_n' and the maturity stages or feeding in _Bupleurogrammus intermedius_ and _Upeneus tragula_ respectively.

The present study revealed that in _P. macrophthalmus_ though the 'relative condition factor' of immature and mature fish varied from month to month, (Pl.XI, fig.4 and 5) the fluctuations did not seem to be related to either the feeding habits or the matuation. Moreover, the geometric mean of the 'K_n' of both immature and mature fishes did not vary much in both years. However the fluctuations in the 'K_n' factor may be due to reasons other than feeding or maturity.

TABLE 74

Geometric mean of condition factor (January 1968 - December 1968)

Months	Immature		Mature	
	No.of fish	Kn.	No.of fish	Kn
January	23	0.95	19	0.99
February	13	0.96	29	1.01
March	22	0.96	20	0.99
April	12	1.02	39	1.00
May	23	1.01	13	1.03
June	32	1.01	11	1.03
July	22	0.97	14	1.00
August	32	1.00	29	0.96
September	32	0.99	28	0.97
October	23	1.07	11	0.98
November	--	--	--	--
December	33	1.00	6	0.98
Total	267		109	

TABLE 75

Geometric mean of condition factor (January 1969 - December 1969

Months	Immature		Mature	
	No.of fish	Kn	No.of fish	Kn
January	23	1.00	15	0.98
February	13	0.99	24	0.97
March	22	0.99	14	0.99
April	2	1.00	4	1.00
May	3	1.00	5	1.00
June	13	1.00	21	0.98
July	21	1.00	32	0.97
August	22	0.99	30	1.00
September	22	0.99	27	1.03
October	32	0.99	21	1.01
November	23	0.99	20	1.00
December	25	0.98	20	1.00
Total	221		233	

V. REPRODUCTION

Introduction:

A knwoledge of the biological factors, such as maturation cycle, size at first maturity, sex ratio, spawning periodicity, fecundity and reproductive load etc. of a fish is essential for proper management of any fish stock. Such studies are basically aimed at understanding and predicting the changes which the population undergoes during the year. Further from these study, information on rate of regeneration of stock, management of resources and the breeding activity of the fish can be gathered. Pioneering work in this field was done by Clark (1934) who studied the maturity of California sardine (Sardina caerulea) by means of ova diameter. Similar work had been done by Hickling and Rutenberg (1936), Hickling (1940), Bagenal (1967 and 1968) and others.

In recent years a good amount of work had been done on the maturity and spawning of Indian fishes. Karandiker and Paleker (1950) studied the maturation of the ovaries in Polynemus tetradactylus; Palekar (1952) observed the spawning habits in Harpodon neherew, Seshappa and Bhimachar (1955) described the maturation in Cynoglossus semifasciatus; the maturity and the spawning habits of Thrissocles purava Harpodon nehereus and Coilia dussumieri were described by Palekar and Karandiker (1952 and 1953) and that of Rastrelliger kanagurta based on the ova diameter was investigated by Ramamohana Rao (1971) and Antony Raja (1967); the maturation of Sardinella longiceps was studied by Dhulked (1967) and Annigeri (1972).

Venkatasubba Rao (1968) described the maturation in Pseudosciaena diacanthus by ova diameter method and condition factor and observed that its spawning season extended from June to September in Bombay coast. Appa Rao (1967 and 1971) investigated the maturation of the sciaenid fishes Johnius ~~sk~~ carutta, Pseudosciaena aneus and P. bleekeri by fat content and ova diameter methods and observed that the breeding season of P. macrophthalmus was during December to March on Waltair coast; Rajan (1968) studied the maturation of Pseudosciaena coibor by gonadosomatic index while Devadoss (1972) described the maturity stages of Johnius dussumieri and Otolithus ruber from Bombay coast by ova diameter and ponderal index methods.

Gopinath (1946) reported post larval stages of the Sciaena albida from Trivandrum coast; Bapat and Bal (1950) collected post larval stages of S. miles, S. albida, S. semiluctousa, S. glauca and Otolithus argenteus from Bombay coast. Chacko (1950) observed larval and post larval stages of Otolithes ruber from the Gulf of Mannar during August and September. The larval development of Pseudosciaena coitor was described by Karamchandani and Motwani (1954) while John (1951) studied the larval and post larval stages of Pseudosciaena aneus from Madras. According to Pantulu and Jones (1951) Pama pama spawn throughout the year in the Hooghly river.

Though the above works have considerably augmented our knowledge on the reproduction of the sciaenid fishes from different parts of India, there is no comprehensive account of all the aspects of reproduction of sciaenid fishes. In view of this paucity of knowledge the present study on the maturation, spawning, sex ratio, fecundity of Pennahia macrophthalmus, which formed one of the commercially important sciaenid fishes of Palk Bay was taken up.

Material and methods:

Bi-weekly collections were made during 1968 and 1969. Fishes were preserved in 5% formolin in the field and were brought to the laboratory.

The distribution of ova in the ovaries was studied by selecting an ovary in 4th stage of maturity (Pl.XII, fig.3-5). Ova were taken from the anterior, middle and posterior portion of the ovary, placed on a microslide and examined with a microscope. The data were plotted and the frequency polygon was drawn with diameter of ova along the 'X' axis and their percentage of 'Y' axis (Plate XII, Fig.3-5). The stages of maturity were determined by observing the size of the ovary in relation to the body cavity and by the microscopic examination of the ova. Ova diameter measurements of 97 ovaries belonging to I to VII stages were examined. From the middle portion of the right ovaries samples were taken and about 500 eggs were measured to draw the ova diameter polygon. The spawning season was determined by examining 1915 and 748 specimens during 1968 and 1969 respectively. The gonadosomatic index was calculated based on the weight of ovary and weight of fish following the formula:

$$\frac{\text{Weight of ovary (gm)}}{\text{Weight of fish (gm)}} \times 100 \quad .. \qquad (13)$$

The index was found for mature and ripe females and the average was calculated for each month.

To determine the length at first maturity 2547 specimens were examined. The fishes were classified into 5 mm length groups and the percentages of various stages of maturity were calculated. Total length of fishes were plotted along X-axis and the percentage of maturity on Y-axis. An intercept was drawn at 50% to meet the curve. A vertical line was drawn from the meeting point of the curve and the intercept. The point where the vertical line meets the X-axis indicated the length at first maturity, which was also the length at which 50% of the fishes attained the maturity. Length at first maturity was also determined by plotting the average size of mature ova of various length groups against the total length. Similarly weight at first maturity was determined by plotting the relative ovary weight X 10^3 against the weight of fish. The relative ovary weight was obtained by dividing weight of gonad by weight of fish.

Relation between ova diameter and relative ovary weight X 10^3 and ova diameter and total length were determined by plotting the relative ovary weight X 10^3 and model ova diameter and total length and largest mean ova diameter.

Fecundity studies were based on 17 specimens. The ovaries were removed and the excess of moisture was blotted from the ovary with a blotting paper. The ovaries were weighed nearest to 0.1 mg. A piece of ovary was taken from the central portion and weighed in a watch glass. Weight of watch glass was taken separately. The difference between the two (?) the gave the weight of the sample. The ova were separated from the follicular membrane with the aid of two fine dissecting needles. The number of mature ova in the sample was counted. The total number of ova in the ovary was found by using the formula

$$\frac{\text{Number of ova with sample X weight of ovary}}{\text{Weight of sample}} \quad .. \ (14)$$

Fecundity and total length, fecundity and weight of fish, fecundity and weight of ovary and length of gonad and total length of fish were also plotted separately to find out their relationship. The linear relation between fish and gonad lengths were analysed by studying 151 females and 118 males of length 75 to 195 mm. The equation (9) was fitted to females and males separately. Similarly the relationship between length and weight of ovaries of mature and immature fishes was also worked out by using the above mentioned ~~fxxmxk~~ formula (9).

About 2600 fishes of length 70 to 207 mm were examined for sex ratio. Sex of the sp cimens was determined by macroscopic and microscopic examinations as mentioned before. The total length and sex were noted and the data was tabulated for each month and tested by using X^2 - test to find out whether the ratios were significant 5% level. To find out whether the sexes of different length groups deviated from 1:1 ratio the fishes were classified into 5 mm length groups and tested by X^2 - test.

Reproductive organs

A pair of gonads is suspended laterally from the dorsal wall of the coelomic cavity on either side by mesovarium or by a mesorchium. Posteriorly the gonads open to the exterior by a common duct through a common genital opening.

Ovaries: The ovary of *P. macrophthalmus* is bilobed and equal in size. It is narrow and elongated in the immature specimens and increased in length and breadth as stages of maturity advances. In advance stages the posterior ends of the ovaries are fused.

Testes: The testes are thin and thread like in earlier stages and enlarge in mature specimens. Fully mature testes are flat and appear fleshy and milky white in colour.

Though as a general rule both the ovaries and testis are symmetrical, a few abnormal gonads are also reported (Mohan, 1970).

Maturation:

1. Distribution of ova in the Ovary: To find out whether there was any unequal distribution of ova in the ovary of *P. macrophthalmus*, a mature ovary of stage IV was selected. Three sections were made from the right and left lobes of the ovary. The ova from the different regions of right and left ovaries were plotted (Pl.XII, fig.4), and it was found that the ova of right and left lobes were almost in the same

stages of maturity. Similarly the ova from the anterior, middle and posterior portions of the ovary were also examined (Pl.XII, fig.5). The frequency polygons showed a similar pattern of distribution of immature, maturing and mature ova in all the three portions of the ovary. The ova diameter of various portions of left and right and left lobes of the ovaries were pooled (Pl.XII, Fig.3). This showed that the ova were evenly distributed in the different portion of right and left ovaries.

In all the stages of maturity immature ova measuring below 0.2 mm were present throughout the year and these were not measured as done by earlier workers like Clark, (1934), de Jong (1940) and others.

Based on the macroscopic structure and the microscopic examination of the ova, seven stages of maturity corresponding to those devised by the International Council for the Exploration of the Sea (Wood, 1930), was followed ~~by~~ for Pennahia macrophthalmus (Table76).

Classification of the maturity stages:

Stage 1 (Immature) (Pl.XII, fig.1);- Ovaries thin and transparent occupying less than one fourth of the body cavity. Ova not visible to naked eye and transparent with a nucleus at the centre. Yolk not formed; most of the ova diameter ranged from 0.2 to 0.3 mm with a mode at 0.24 mm.

Testes short, slender and fleshy white.

Stage II (Early maturing):- Ovaries slightly bigger than the earlier stage occupying nearly one third of the body cavity. The first batch of eggs separated from the general stock. Ova irregular in shape. Eggs partly opaque due to the commencement of the deposition of yolk. The ova diameter ranged from 0.30 to 0.45 mm with a mode at 0.41 mm and appears pale yellow. In this stage of maturity, maturing virgins and spent recovering stages are also included.

The testes are narrow, occupying about one fourth of body cavity.

Stage III - (Late maturing):- Ovary occupy about three fourths of body cavity and yellowish in colour. The ovarian membrane thick, eggs spherical, opaque, fully yolked and visible to naked eye. The ova diameter measured 0.30 to 0.57 mm with model value at 0.49 mm.

Testes white, slightly bigger than the earlier stage.

Stage IV - (Mature) (Pl. XII, fig.1):- Ovaries large, yellowish occupying almost the entire body cavity; ova spherical, opaque, fully laden with yolk with an indistinct oil globule measuring 0.1 mm; ova 0.57 to 0.65 mm with a mode at 0.61 mm.

Testes slightly larger than the earlier stage and white in colour.

Stage V - Ripe) (Pl.XII, Fig.1):- Ovaries with a fleshy tint, turgid, occupying the entire body cavity. Ovarian membrane thin with many blood vessels. Ova fully developed, transparent and spherical; oil globules well developed, slightly yellowish, 0.2 mm in diameter; ova diameter 0.61 to 0.81 mm with a mode at 0.69 mm.

Testes creamy white and ribbon shaped, extending to the whole length of body cavity.

Stage VI - (Spawning):- Ovary with free ova, which ooze out on pressing the abdomen. Ova completely transparent, single oil globule yellowish, spherical about 0.2 mm in diameter. Ova diameter from 0.8 to 1.0 mm.

Testes white and fleshy, spermatozoa ooze out at slightest pressure. The margin of testes convoluted.

Stage VII :- This stage comprises of partly spent and fully spent ovaries. The partly spent ovaries are with a few residual ova and large number of immature and ripe ova. The spent ovaries are with large of immature and a few residual ova. Some of the residual ova are seen with burst oil globules, reduced yolk and shrivelled vitelline membrane; ova with empty vitelline membrane having no yolk or oil globules are also encountered. Residual ova measures 0.5 to 0.8 mm and the immature ova measures 0.3 to 0.5 mm.

Testes shrivelled occupies about half of the body cavity.

Growth of ova to maturity:

As the ova measuring below 0.10 mm were found in all stages of maturity, only those above 0.10 mm were taken into consideration. The ova diameter studies were made with an ocular micrometer (1 MD = .02 mm) . As seen in the ova diameter frequency polygon of a mature ovary (Pl.XII, fig.5), ova were in three stages of maturity. The first stage belonging to immature stock measuring below 0.3 mm, the second stage of maturing stock measuring 0.40 to 0.52 mm and the matured ova of 0.57 to 0.68 mm or more.

In stage I (immature ovary) most of the ova were transparent measuring upto 0.3 mm with a central nucleus. In stage II (maturing or spent recovering), while the majority of the ova were small and transparent, a group of ova were separated from the general stock with a mode at 0.41 mm, measuring 0.30 mm to 0.45 mm. In Stage III (maturing) the eggs which separated from the general stock attained modal size of 0.49 mm and measured between 0.37 to 0.57 mm. These ova were fully laden with yolk and became spherical. In stage IV (mature) ova were spherical, fully laden with yolk having an indistinct oil globule of diameter 0.1 mm and measuring 0.57 to 0.69 mm with a mode at 0.61 mm. These ova became stage V with a well developed oil globule of 0.2 mm in diameter and the ova measuring 0.59 to 0.80 mm with the modal value of 0.69 mm. In spawning ovaries(stage VI) the ova were spherical, transparent with yellowish oil globule measuring 0.2 mm in diameter. The ova measured 0.70 to 0.99 mm with a mode at 0.79 mm. These ova were separated from the general stock of ova which measured 0.31 to 0.38 mm. In spent ovaries (VII) immature ova measured 0.31 to 0.40 mm and the residual ova were in various stages of absorption measured 0.50 to 0.79 mm with a mode at 0.71 mm. Though the absence of residual eggs in the ovaries may not be accepted as a proof that a fish has not spawned, their presence is a good evidence that spawning has occurred. From the ova diameter frequency polygons it was observed that only one batch of ova was separated from the general stock and became mature. Although in stage IV two modes were seen the second mode disappeared probably consequent upon faster growth of mature ova (Pl.XII, fig.1).

Spawning:

According to Hickling and Rutenberg (1936) and de Jong (1940) teleostean fishes are found to exhibit mainly four type of spawning habits. (1) A short spawning, once in a season. The mature ovaries show immature and mature ova distinctly separated from each other. (2) Spawning takes place once but over a long period. The size range of mature ova be approximately half the total range in size of ova. (3) Spawns twice in a season. Ovaries with mature ova and another group of ova which has undergone about half the maturation process. (4) Spawns intermittently over a long period. Ovaries have successive batch of ova which are not sharply differentiated.

Though an examination of the ova diameter frequencies of the mature ovary, showed a prominent mode and less prominant modes, that of the ripe ovaries were with one distinct mode (Pl.XII, Fig.1). The frequency polygon of the ovaries of the spawning individuals presented one distinct mode of ripe ova and another widely separated one of immature ova. This showed that P. macrophthalmus belongs to the group which breeds once in a season with a prolonged spawning period.

The spawning ovaries were having ripe ova ranging from 0.72 to 0.99 mm. This showed that all the eggs were not spawned at spurts of breeding acts restricted to a short time. This view was further supported by the fact that an oozing specimen with transparent ova measuring 0.70 to 0.82 mm was collected from Rameswaram on March 4, 1969.

Recently spent ovaries with a few residual eggs in various stages of absorption were recorded. The residual eggs were irregular in shape with partly or completely absorbed yolk and the absorption of the yolk resulted in the collapse of chorin. Oil globules were also in various stages of degeneration and in some ova the ruptured oil globules were seen as droplets. A few residual eggs with neither yolk nor oil globules, were observed in a specimen of length 188 mm collected from Rameswaram on March 24, 1969.

Spawning season:

In January, 1968 maturity stages I to IV were present with stage II dominating. During February stages I to V occurred with II and III stages as dominant ones. In March although the stages I to V were present the stage III was predominant. During April, stages I to IV were present with stage III dominating. A similar trend was seen in May also. In June though stages I to V were present, stage I dominated probably due to the occurrence of juveniles recruited during March and April. In July and August stages I to IV occurred with stage III dominating. In September, October and December stage II was dominant though stages I to III stages were encountered with stage IV forming less than 1% indicating that most of the fishes were in resting stage (Pl.XIII, fig.1).

Similarly in 1969 the stages I to IV occurred during January with stage II dominating. In February, and March stages II to VII occurred with stage III as the dominant one. In these months spawning and spent specimens occurred indicating peak spawning. In April, stages III, IV and V stages occurred with dominance of stage III. In the month of May, stages II, III and IV occurred with the stage II dominating. In June, July and August stages I to IV occurred with the stage III dominating. During September stages I to IV occurred with a dominance of stage II. In October, November and December stages I to III occurred with stage II as dominant one. During this season the gonads of some fishes were in 'resting' period while others were in spent recovering stage. From the Table (77) it may be seen that stage V continued to occur from February to April though stages VI to VII occurred during

February and March (Table 78). The gonadosomatic index (Pl.XII, Fig.2) also recorded high value from February to August indicating extended spawning season. Further the occurrence of juveniles 35 to 54 mm during July supported the view that peak spawning was during March and April.

41 Spawning frequency:

A single mode of ripe ova 70-90 mm in diameter that was seen in the ova diameter frequency polygon of stages V and VI clearly showed that spawning occurred only during a short time. Further, the occurrence of free ripe ova in the ovaries of the oozing specimens showed that all eggs were not spawned at a single spurt, but batches of ova were spawned at close intervals.

Gonadosomatic index:

The Gonadosomatic index was studied to find out the maturity of the fish during various months. The average gonadosomatic indices for the years 1968 and 1969 were 3.20 and 2.98 (Table 79). The gonadosomatic index was more than 3.5 and less than 2.0, for mature and immature fishes respectively. It could be observed (Pl.XII, Fig.2), that there was a peak in February and March during 1968 and 1969 indicating the peak breeding season. However, gonadosomatic index was more than 3.5, from February to August in 1968 and March to July in 1969, showing that the fish matured during the months. The over all average index for the two years was found to be 3.03 which was close to the index of mature fishes.

Studies on first maturity:

Length at first maturity by graphical method:

For the purpose of calculating the length at first maturity, fishes belonging to the stages other than I and II were grouped as mature fishes. Since the stages of maturity were more evident in the ovaries than testes, the females were separated and the L_m (length at first maturity) was calculated for both years separately. L_m for females during 1968, 1969 and for the pooled data for both years were found to be 129 mm, 135 mm and 135 mm respectively (Tables 80-84; Pl.XIV, fig.1-3).

The reproductive load

$$\frac{L_m}{L_\infty} \quad .. \quad .. \quad .. \quad .. \qquad (15)$$

where L_m is the length at first maturity and L_∞ is asymtotic length for the females was found to be 0.538 in 1968, 0.562 in 1969 and 0.562 for the pooled data for both sexes during 1968 and 1969.

Length at first maturity by ova diameter studies:

As the fishes became mature only after 130 mm, the fishes above 100 mm were only taken for this study. Three groups of ova, immature, maturing and mature were observed (Pl.XIII, Fig.4). Immature ova occurred in all the length groups representing the general stock of ova and most of the ova of fishes measuring less than 130 mm of total length were of 0.4 mm in diameter.

The mature ova measuring 0.6 mm to 1.0 mm occurred only after 135 mm oftotal length. It confirms the earlier observations of the present study indicating that the species matured at about 135 mm of total length.

Weight at first maturity:

Weight at first maturity was determined by June (1953) in yellowfin tuna, by plotting the relative ovary weight X 10^3 and weight of fish. It was observed (Pl.XIV, Fig.8) that the index 30.0 or more occurred in fishes weighing more than 35 gms. From the length-weight regression line it could be seen that 35 gms of fishes measured about 130 mm in length. This further supports the earlier observation that the length at first maturity is between 130 - 135 mm.

Relation between ova diameter and relative ovary weight:

The ova diameter of P. macrophthalmus was observed to increase with the weight of gonad (Pl.XIV, Fig.7) and the relative ovary weight X 10^3 for immature ovaries was found to be below 30.0 and that of mature ovaries were between 30 to 70. The ovaries with the index below 30 had the modal ova diameter below 0.5 mm.

Relation between ova diameter and total length:

To assertain the length at first maturity, the relation between total length and largest mean ova diameter were also studied (Pl.XIII, Fig.4). Though the immature ova occurred in all length groups, the mature ova (more than 0.5 mm) occurred only in fishes above 135 mm. Ova measuring less than 0.5 mm representing immature ova were found in fishes of length below 130 mm. This observation again agrees with the earlier observations that *P. macrophthalmus* matures at about 135 mm in length.

Fecundity:

Estimation of fecundity:

The reproductive potential of a population has a great bearing on the population dynamics of the fish. The fecundity estimations are based on th assumption that all the ova comprising the most advanced group are released in a single spawning though it need not necessairly be so. However to make all the estimates comparable, only ovaries of stages IV and V showing no sign of previous spawning during the season were taken for this study.

Fecundity was estimated by finding out the total number of mature ova in the ovary as mentioned earlier. The total number of ova was found to be from 13405 to 44167. The mean fecundity of the 17 specimens was estimated to be 30207 (Table 85).

Relationship between fecundity and total length:

This relationship was studied so that if one factor was known the other could be estimated. As the scatter due to the individual variation was found to be great (Pl.XIV, Fig.6) it was not possible to derive any relationship between them. Smaller fishes were found to have more ova and larger fishes were having less number of ova. Hence fecundity was not related to the length of fish.

Relationship between body weight and fecundity:

Here also it was not possible to establish any relationship between weight of the fish and fecundity, eventhough the fecundity increased with weight of fish. It was evident that there was wide scatter due to individual variation. (Pl.XIV, Fig.5).

Relationship between weight of ovary and fecundity:

Here also no relationship could be established between weight of ovary and fecundity due to the marked individual variation (Pl.XIV, Fig.4).

Relationship between total length and the length of gonad:

The study of relation between the length of fish and the length of gonads may be useful as an index of maturity of the species. Generally a linear relationship was observed between the length of fishes and the length of gonads.

Scatter diagrams (Pl.XIII, 2 & 3) indicated a linear relationship. Hence the equation (9) was fitted to the data. The equation for the female was found to be:

$$Y = -28.8609 + 0.4284\ X \quad .. \qquad (16)$$

were 'Y', the length of gonad and 'X', the length of fishes. The equation for the male was found to be:

$$Y = -26.5731 + 0.4102\ X \quad .. \qquad (17)$$

As the regression coefficient 'b' was less than unity in both cases, the rate of growth of the gonads was less than the rate of growth of the fishes.

<u>Relationship between weight and length of ovaries:</u>

This study is useful as it may throw light on the growth pattern of immature and mature ovaries in relation to its length and weight. The relation between the weight and length of immature ovaries was curvilinear (Pl.XI, Fig.6) where as that between length of mature ovaries and weight was linear. The relation between the weight and length of immature ovaries was:

$$\log Y = -4.0858 + 3.1341 \log X \quad .. \qquad (18)$$

where Y is the weight and X is the length of the ovaries. The formula for the mature ovary was found to be:

$$Y = -14.7075 + 0.7491\ X \quad .. \qquad (19)$$

In the former case as the 'b' value is approaching 3, cubical relationship is observed whereas in the latter case as the 'b' value is less than unity their relationship is not cubical.

<u>Sex ratio:</u>

Sex ratio in fishes was studied with the object of finding out the ratio the sex during the spawning season and to establish whether there is any correlation between the sex of different size groups. Sex ratio ~~in~~ had been investigated in many fishes by earlier authors. It was be observed that in P. macrophthalmus the sex ratio was approximately 1:1 during most of the months. The data was analysed by using X^2 - test and it was found that the ratio was not significant at 5% level during the breeding season in 1968 and 1969 (Table 86)

Sex ratio between different size groups were analysed to establish whether there was any difference between them. It was observed (Table 87) that there was a dominance of males in length group 70 to 124 mm and the sex ratio deviated from the 1:1 ratio at 5% level in this groups. But the ratio of the 125 - 149 mm length groups did not deviate from 1:1 ratio at 5% level. It may be mentioned that the fishes matured at about 130 mm. Though in 1968 the sex ratio of the length group 150 to 205 mm differed significantly from 1:1 ratio, there was no such difference during 1969. In 1968 the sex ratio was found to be 1.0 : 1.1 whereas in 1969 it was 1:1. But the average sex ratio for the both years 1968 and 1969 were found to be 1.0:1.1 which was not found to be significant at 5% level.

<u>Discussion:</u>

A perusal of the literature showed that various authors have classified the maturity stages based on various criteria (Qasim, 1973). Size of the gonad in relation to the body cavity, ova diameter, fat content and gonado somatic index were some of the methods of commonly used.

Though as many as 10 stages of maturity were defind in fishes (Antony Raja, 1967), Qasim 1973 suggested 5 maturity stages viz., immature virgins, maturing virgins or recovering spents, ripening, ripe and spent. However, various authors classified the maturity stage according to the condition of the gonads noticed in the fishes they were studying. In this study gonads were classified into seven stages based on Wood (1930).

The growth of ova was followed from immature to residual eggs. In the mature ovary, ova were in three stages of maturity namely immature, maturing and matured. But in spawning individuals only by immature and ripe ova were observed. As the stock of immature ova were well separated from that of ripe ova the fishes might be spawning once in a year. Spawning individuals with oozing ova and spent specimens with residual eggs in various stages of obsorption were also observed from February to March indicating that the peak breeding might be during this period.

The study of L_m, the length at first maturity is important as it is related to L_∞, the asymptotic length. Holt (1962) observed that the fishes become mature at a size which is some rather constant proportion of the final length. Beverton and Holt (1959) compiled the ratio of mean length at first maturity to the asymptotic length of many species and found that it varied considerably. Beverton (1963) established relationship between L_m and L_∞ for a number of clupied fishes of different familes. Cushing (1968) observed that bigger the fish, bigger it is at first maturity. The study of length at first maturity is important as it leads to the understanding of L_m/L_∞ ratio which is also known as reproductive load. The reproductive load is related to M/K ratio where 'M', the mortality rate and 'K', the rate at which growth to the asymptote decreases.

The length at first maturity was studied by ova diameter method and by plotting the maturity stages and length of fish. More or less same results were obtained by both the methods. P. macrophthalmus was observed to attain maturity at about 130 mm.

While studying the yellow fin tuna, June (1953) and Yuen (1955) found that the relative ovary weight X 10^3 when plotted against the modal ova diameter explained the state of maturity of fishes. This relationship was worked out for P.macrophthalmus also. It was found that the matured ova measured 0.5 mm or more, confirming the earlier observation.

Fecundity is known to vary within a species due to the length or age of a fish. Fluctuation in the fecundity of Sardinella longiceps was investigated by Antony Raja (1972). The study on the fecundity may help to establish the relationship between length of fish, weight of fish, length of gonad and the size of ova. Many workers have established relationship between fecundity and square of length of fish (Franz, 1910 a & b) and (Clark, 1934). Pitcher and Macdonald (1973) found that the number of eggs spawned by a fish of a given size can be estimated from a power curve of length, the parameter of which can be calculated by log/log regression. They also observed that it is better to relate fecundity to fish length because the number of eggs are not independent of weight and lengths are more consistant and easily measured. Farran (1938) observed that the fecundity increased at the rate higher than fourth power of length. But Hickling (1940) observed that the fecundity of the herring increased at a rate greater than third power of its length. A straight line relationship between the number of ova and length of fish was observed in eastern trout by Smith (1947). In *Pleuronectes platessa* the fecundity was related to the cube of length (Simpson, 1951), Lehman (1953) also found a linear relationship between total length and fecundity in shad *Alosa sapidessima*. Macgregor (1957) while discussing the relationship between fecundity and length in *Sardinops caerulea*, found that there was no significant variation in the regressions on length, square of length or cube of lengths. Pillai (1958) observed exponential relationship between fecundity and length of fishes and a straight line relationship between fecundity and weight of fish in *Hilsa ilisha*. In *Osteogeneiosus militaris* fecundity increased at a rate less than the body weight in relation to length whereas the ovary weight increased at a more rapid rate in relation to length than body weight and the rate of increase in fecundity (Pantulu, 1963). Pai (1968) also found linear relationship between weight of fish and fecundity in Psammoperca waigiensis. However, James (1967) while studying Dupleurogramus intermedius found no relationship between fecundity and weight of fish, fecundity and length of fish and fecundity and weight of ovary.

In the present study it was not possible to establish any relationship between fecundity and total length, and weight of fish and fecundity and weight of ovary. However, a linear relationship was obtained for total length and length of gonads and weight and length of mature ovaries. Further a curvilinear relationship was seen between weight and length of immature ovaries.

Sex ratio was studied with the object of understanding the ratio of sexes during various months and between the lengh groups. Jones and Menon (1951) while working on the hilsa at Hooghly river found 1:1 ratio with preponderence of females during breeding season. Pillay (1958) and Pai (1968) also found 1:1 ratio in hilsa and Psammaperca waigiensis respectively. It was observed in P. macrophthalmus that there was dominance of males in immature specimens and the ratio approached 1:1 ratio in mature specimens. However, the average sex ratio for 1968 and 1969 were found to be 1.0:1.1 which was not significant at 5% level.

TABLE 76

Maturity stages of *Pennahia macrophthalmus* along with corresponding stages for I.C.E.S. (Wood, 1930).

Stage of maturity	Stages of intraovarian ova	Mode of ova (mm)	Size range of ova (mm)	Stages defind by I.C.E.S.
I	Immature	0.24	0.20 - 0.30	I
II	Maturing	0.41	0.30 - 0.45	II
III	Maturing	0.49	0.37 - 0.57	III
IV	Mature	0.61	0.57 - 0.65	IV
V	Ripe	0.69	0.65 - 0.81	V
VI	Spawning	0.85	0.80 - 1.00	VI
VII	Spent	0.72	0.60 - 0.80	VII

TABLE 77

Maturity table for the year 1968

Months	No. of fishes	Stages of maturity (%)				
		I	II	III	IV	V
January	75	28.0	58.6	8.0	5.4	-
February	184	12.5	39.1	32.0	14.7	1.7
March	230	0.9	22.6	55.3	16.5	4.7
April	218	4.6	14.7	62.0	18.7	-
May	253	10.6	22.6	60.0	6.4	0.4
June	232	41.3	15.1	34.1	9.1	0.4
July	215	14.8	34.5	45.2	5.5	
August	140	25.7	25.1	46.4	2.8	
September	181	16.2	45.8	37.5	0.5	
October	159	10.6	55.3	33.4	0.7	
November	-	-	-	-	-	-
December	28	3.6	89.3	7.1		

TABLE 78

Maturity table for the year 1969

Months	No. of fishes	Stages of maturity (%)						
		I	II	III	IV	V	VI	VII
January	75	12.0	62.9	20.1	5.0	-	-	-
February	45	-	13.4	48.8	20.0	4.5	11.1	2.2
March	90	-	16.6	47.8	6.7	-	13.3	15.6
April	17	-	20.0	53.3	13.2	13.5	-	-
May	12	-	50.0	33.3	16.7	-	-	-
June	84	28.5	29.8	38.1	3.6	--	-	-
July	146	17.8	36.9	39.1	6.2	-	-	-
August	87	10.3	34.5	39.1	16.1	-	-	-
September	36	30.5	36.1	25.1	8.3	-	-	-
October	46	4.4	84.8	10.8	-	-	-	-
November	63	36.5	44.5	19.0	-	-	-	-
December	47	40.5	44.7	14.8	-	-	-	-

TABLE 79

Details of the fishes selected for fecundity studies

Sl. No.	Fish length (mm)	Fish weight (gm)	Ovary length (mm)	Ovary weight (gm)	No.of ova	Maturity stages	Date of collection
1.	140	33.4	48.0	3.0	27543	IV	11-2-69
2.	155	50.0	41.0	2.3	30017	IV	17-2-69
3.	160	55.2	49.0	2.7	28340	V	11-2-69
4.	167	73.4	51.0	3.0	20571	IV	16-3-69
5.	170	87.3	56.0	6.3	34257	IV	24-7-69
6. 1	170	90.0	50.0	6.0	37295	IV	24-7-69
7.	171	81.2	53.0	6.1	21596	IV	5-7-69
8.	174	91.5	54.0	6.0	33832	IV	24-7-69
9.	176	92.5	49.0	6.0	44167	IV	26-7-69
10.	178	94.0	58.0	6.3	43729	IV	19-7-69
11.	179	98.8	60.0	5.6	29293	V	28-2-68
12.	181	91.4	48.0	2.8	42720	IV	26-3-69
13.	184	96.5	66.0	7.0	16802	V	28-2-69
14.	185	105.0	54.0	5.6	13405	V	19-6-69
15.	188	104.5	50.0	4.2	41450	IV	5-2-68
16.	189	101.9	51.0	3.9	27882	IV	24-2-69
17.	191	102.1	62.0	5.2	20534	V	28-2-69

TABLE 80

Percentage of occurrence of maturity stages in various size groups for the year 1968 (Males and Females)

Length groups (mm)	No.of fishes	Stages of maturity						
		I	II	III	IV	V	VI	VII
70-74	2	100.0						
75-79	18	100.0						
80-84	17	100.0						
85-89	24	100.0						
90-94	18	100.0						
95-99	27	85.1	14.9					
100-104	38	78.9	21.1					
105-109	34	58.8	41.2					
110-114	68	47.0	39.8	13.2				
115-119	103	42.8	37.8	19.4				
120-124	117	14.5	58.9	26.6				
125-129	154	14.2	44.8	37.6	2.6	0.8		
130-134	201	3.5	39.5	51.0	6.0	-		
135-139	162	2.5	38.8	51.2	6.6	0.9		
140-144	179	0.7	37.4	51.9	10.0	-		
150-154	192	1.1	30.7	54.6	12.5	1.1		
155-159	129	1.5	28.3	57.8	11.6	0.8		
155-159	78		11.3	68.4	17.7	2.6		
160-164	72		19.4	61.1	18.0	1.5		
165-169	47		11.2	67.5	19.1	2.3		
170-174	51		7.0	79.0	12.0	2.0		
175-179	25		2.0	78.0	12.0	8.0		
180-184	15			59.9	26.6	13.5		
185-189	10			80.0	20.0	-		
190-194	5			40.0	40.0	20.0		
195-199	6			16.6	83.4			
200-204					100.0			

TABLE 81

Percentage of occurrence of maturity stages in various size groups for the year 1969 (Males and Females)

Length groups (mm)	No. of fishes	Stage of maturity						
		I	II	III	IV	V	VI	VII
85-89	9	100.0						
90-94	3	100.0						
95-99	6	100.0						
100-104	5	100.0						
105-109	19	94.0	6.0					
110-114	37	59.4	37.8	2.8				
115-119	38	47.3	39.4	13.3				
120-124	51	21.5	58.5	20.0				
125-129	52	17.3	50.0	26.7	2.0	2.0	2.0	
130-134	64	10.3	42.0	45.9	1.8			
135-139	53		42.8	51.4	5.8			
140-144	66		36.8	49.7	8.6		1.7	3.2
145-149	59		30.0	58.8	3.2		3.2	5.6
150-154	66		11.8	71.5	9.2	1.5	4.5	1.5
155-159	75		1.9	29.7	10.5	1.3	2.6	4.0
160-164	49			83.6	8.2		8.2	
165-169	37			56.7	24.3		5.5	13.5
170-174	25			64.0	28.0		4.0	4.0
175-179	17			63.1	35.2		11.7	
180-184	7			14.2	57.4		28.4	
185-189	10			60.0	30.0			10.0
190-194	2			50.0	50.0			
195-199	2			50.0	50.0			

TABLE 82

Percentage of maturity stages in various size groups in 1968 and 1969 for Males and Females

Length groups (mm)	No. of fishes	Stages of maturity						
		I	II	III	IV	V	VI	VII
70-74	2	100.0						
75-79	18	100.0						
80-84	17	100.0						
85-89	33	100.0						
90-94	21	100.0						
95-99	33	87.8	12.2					
100.104	43	81.3	18.7					
105-109	53	71.6	28.4					
110-114	105	51.4	39.0	9.6				
115-119	141	43.9	38.2	17.9				
120-124	168	16.6	63.0	20.4				
125-129	206	15.0	46.2	34.9	2.4	0.5	0.5	0.5
130-134	265	7.5	40.0	47.5	5.0			
135-139	215		46.0	46.9	6.2	0.9		
140-144	244		42.2	47.5	9.0		0.4	0.9
145-149	251		35.0	52.3	9.3	1.6	0.8	1.0
150-154	195		30.7	55.3	10.7	1.1	1.5	0.7
155-159	154		16.8	64.2	14.2	1.3	1.3	2.2
160-164	121		11.5	70.3	14.0	0.9	3.3	
165-169	84		5.9	63.0	21.4	1.2	2.6	5.9
170-174	77		2.5	75.3	16.3	16.8	1.5	2.4
175-179	42			69.2	21.4	4.7	4.7	
180-184	22			45.4	36.4	9.1	9.1	
185-189	20			70.0	25.0			5.0
190-194	7			42.8	42.8	14.4		
195-199	8			87.5	12.5			
200-204	2						100.0	
205-209	1						100.0	

TABLE 83

Percentage of occurrence of maturity stages in various size groups for the year 1968

Length groups (mm)	No.of fishes	Stage of maturity						
		I	II	III	IV	V	VI	VII
70-74	1	100.0						
75-79	4	100.0						
80-84	3	100.0						
85-89	3	100.0						
90-94	3	100.0						
95-99	8	87.0	13.0					
100-104	18	61.1	38.9					
105-109	12	58.3	41.7					
110-114	14	62.5	25.0	12.5				
115-119	46	52.2	36.9	10.9				
120-124	57	33.3	35.7	31.0				
125-129	72	19.4	40.2	36.2	4.2			
130-134	88	3.4	34.0	52.2	10.4			
135-139	89		35.9	49.4	13.5	1.2		
140-144	91		37.5	47.2	15.3	-		
145-149	82		21.9	57.3	19.5	1.3		
150-154	64		26.5	51.6	20.4	1.5		
155-159	70		11.4	72.9	14.2	1.5		
160-164	50		14.0	66.0	18.0	2.0		
165-169	35		4.7	65.7	29.6			
170-174	31		2.2	68.3	26.2	3.3		
175-179	20			70.0	15.0	15.0		
180-184	26			57.6	42.4			
185-189	8			75.0	25.0			
190-194	5			20.0	40.0	40.0		
195-199	5			80.0		20.0		
200-204	2				100.0			
205-209	1				100.0			

TABLE 84

Percentage of occurrence of maturity stages in various size groups for the year 1969 (Female)

Length groups (mm)	No. of fishes	Stages of maturity						
		I	II	III	IV	V	VI	VII
75-79	3	100.0						
80-84	2	100.0						
85-89	3	100.0						
90-94	1	100.0						
95-99	3	100.0						
100-104	1	100.0						
105-109	5	100.0						
110-114	11	100.0						
115-119	11	72.7	27.3					
120-124	15	72.7	22.3	5.0				
125-129	21	26.6	73.4	-				
130-134	28	14.4	61.9	19.0	4.7			
135-139	31		53.5	46.5				
140-144	33		41.9	51.7	3.2		3.2	
145-149	35		40.0	44.4	3.3		9.0	3.3
150-154	48		27.4	69.7				2.9
155-159	43		22.9	58.3	10.4	2.1	4.2	2.1
160-164	29		20.5	67.8	6.9	2.4	2.4	-
165-169	21		15.1	67.6	6.8	[illegible]	10.5	
170-174	17		4.5	48.0	38.0			9.5
175-179	12		2.7	73.9	17.6		5.8	
180-184	7			50.0	41.6	8.4		
185-189	7			14.4	71.4			14.3
190-194	2			28.5	57.2			14.3
195-199	1			50.0				50.0
200-204	3			100.0				

TABLE 85

GONADO-SOMATIC INDEX OF *PENNAHIA MACROPHTHALMUS* FOR THE YEAR 1968 AND 1969

Months	1968 Gonado-somatic index	1968 No. of fishes	1969 Gonado-somatic index	1969 No. of fishes	Mean gonado-somatic index for 1968 & 1969
January	1.40	10	2.85	24	2.11
February	3.70	15	3.29	18	3.49
March	3.90	14	4.60	24	4.25
April	4.23	23	3.93	4	4.08
May	4.19	17	4.17	5	4.18
June	4.12	20	3.65	19	3.99
July	4.14	20	3.51	22	3.95
August	3.54	27	3.08	21	3.31
September	3.03	20	2.12	8	2.57
October	2.44	23	1.87	9	2.15
November	-	-	1.50	14	1.50
December	1.52	12	1.27	11	1.38
Mean ($\overline{X}$)	3.20	-	2.98	-	3.03

TABLE 86

Sex ratio of *Pennahia macrophthalmus* for the years 1968 & 1969

	1968				1969			
Months	Female	Male	No.of fishes	X^2	Female	Male	No.of fishes	X^2
January	39	36	75	0.12	46	29	75	3.85*
February	95	89	184	1.19	28	17	45	2.68
March	124	106	230	1.41	55	35	90	4.44*
April	109	110	219	0.01	7	10	17	0.53
May	112	139	251	2.90	5	7	12	0.33
June	107	124	231	1.24	24	60	84	15.42**
July	97	116	213	1.68	72	74	146	0.03
August	56	84	140	5.60*	41	46	87	0.03
September	76	105	181	4.63*	11	25	36	5.44*
October	54	96	150	11.76**	23	23	46	0.00
November	-	-	-	-	46	17	63	13.35**
December	13	15	28	0.14	27	20	47	1.04

* Significant at 5% level; ** Highly significant at 5% level

TABLE 87

Sex ratio according to the size groups for the year 1968 and 1969

	1968				1969			
Size groups (mm)	Female	Male	Total	x^2	Female	Male	Total	x^2
70-74	1	1	2	0	-	-	-	-
75-79	4	14	18	5.5*	3	-	3	3.0
80-84	3	14	17	7.1*	-	-	-	-
85-89	3	27	30	19.2**	0	9	9	8.8*
90-94	3	16	19	8.4	1	2	3	0.3
95-99	8	20	28	5.1	3	3	6	0
100-104	17	20	37	0.2	1	4	5	1.8
105-109	12	23	35	3.4	5	14	19	4.5*
110-114	16	56	72	22.2**	11	26	37	6.1*
115-119	43	65	108	4.5*	11	27	38	6.7*
120-124	57	84	144	6.2*	14	37	51	13.9**
125-129	72	85	157	1.1	21	31	52	1.9
130-134	88	107	195	1.8	28	36	64	1.0
135-139	89	92	181	0.1	31	22	53	1.5
140-144	91	110	201	1.7	31	35	66	2.4
145-149	82	102	184	2.1	35	24	59	2.0
150-154	64	88	152	3.8	48	18	66	13.6**
155-159	70	34	104	12.7**	43	32	75	1.6
160-164	50	30	80	5.0*	29	20	49	1.6
165-169	35	12	47	11.2**	19	18	37	0.2
170-174	32	12	44	9.1*	17	8	25	3.2
175-179	21	2	23	15.7**	12	5	17	2.9
180-184	16	1	17	13.2**	6	1	7	3.5
185-189	8	3	11	2.3	7	3	10	1.6
190-194	5	0	5	5.0*	1	1	2	0
195-199	5	2	7	1.2	1	1	2	0
200-204	1	0	1	0.1	-	-	-	-
205-209	1	0	1	0.1	-	-	-	-

* Significant at 5% level; ** Highly significant at 5% level.

VI. AGE AND GROWTH

Introduction

The study of age and growth of fishes is of paramount importance as the knowledge of it is essential for understanding the fluctuations of various year classes of the stock, mortality rate, and deriving population models. Fluctuation in abundance of the resources are often accompanied by changes in size of fish and it is obviously useful to try to find ways of tracing fish of a particular age through the fishery year by year. This study also helps to understand the various biological problems that are closely interrelated with the fishing industry. As stated by Cushing (1968) the age and growth is one of the vital parameters of a population.

Prediction of growth in natural populations of fish is an important aspect of applied problems of fishery management. It is expected that age would be an adequate criterion of size and growth potential. But growth of fish is influenced by environmental conditions such as relative abundance of food and relative density of population. Thus age and growth are intimately correlated as age is a reliable index of size in relatively constant environment.

Putter (1920), Brody (1945) and von Bertalanffy (1938) developed growth equations in which size and difference between size and an ultimate size (L_∞) determines the growth rate.

Paloheimo and Dickie (1966) studied the growth of fishes in relation to food intake, temperature, age, oxygen consumption and metabolic rate and postulated certain mathematical models and equations to explain their interrelationship. These equations have been used by fishery biologist to study the natural population of fishes. But it was observed that these equations could not adequately explain growth in certain fishes, (Ricker, 1958).

Based on the assumption that size is the basic determinant of growth, the simplest mathematical expression to describe growth would be

$$dw/dt = f(w) \quad .. \qquad (20)$$

where (w/t = weight/time) is some function of weight attained. Since growth in weight is rarely observed to be exponential, a modified function involving the two variables is

$$dw/dt = kw^{x} \quad .. \qquad (21)$$

where 'k' establishes the coordinates of the system and 'x' is a functional exponent of weight less than unity. This type of equation appears to be suitable as it parallels empirical description of the relationship between weight and various physiological processes.

Hoffauer (1898) showed that the growth of scales and growth of fishes were closely related. Later Hjort (1914) followed a dominant age group of the sample from the fishery and showed that the number of annuli in the scales increased annually. Lea (1929) found that a poor growth zone of the scales could be followed in the successive years. Delsman (1929) and Hardenberg (1938) stated that the methods employed in subtropical regions were not suitable for the fishes of tropical regions as there was no definite periodicity of sessions. But many Indian workers found that the hard parts like scales, otoliths, opercular bones, pectoral spines and the vertebrae could be useful for the determination of age in fishes. Graham (1929) published a review on the age determination of fishes. Van Oosten (1928) while studying the lake herring *Leucichthys artedi* reviewed age determination by scale studies. Menon (1950) discussed the use of bones other than otoliths in determining age and growth of fishes.

Scales were used for the determination of age based on the growth checks in the fishes *Cynoglossus semifasciatus*, *Anguilla bengalensis*, *Rastrelliger kanagurta*, *Psuedosciaena diacanthus* and *Sardinella longiceps* by Seshappa and Bhimachar (1951), Pantulu (1956), Seshappa (1958, 1972), Rao (1962) and Balan (1968) respectively.

Otoliths (sagitta) were used for the determination of age in *Sardinella longiceps*, *Otolithoides brunneus*, *Pseudosciaena diacanthus*, *Polynemus heptadactylus* and *Rastrelliger kanagurta* by Nair (1949), Kutty (961), Rao (1962), Kagwade (1972) and Seshappa (1972) respectively. Qasim and Bhatt (1964 and 1966)

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pointed out the usefulness of opercular bones for age determination of Ophiocephalus punctatus. Pantulu (1962) found that the pectoral spines could be used for age studies in the cat fishes Mystus gulio, Pangasius pangasius and Osteogeneiosus militaris whereas Saigal (1963) and Singh and Rege (1968) observed that the vertebrae could be used for age studies in Mystus aor and Tachysurus sona respectively.

Mohan (1968) found that the radiographic technique could be employed to study the growth checks in the otoliths. But hard parts could not be used for age studies in all fishes. Thomas (1969) could not use otoliths for age determination in Parauppeneus tragula; Pai (1968) also could not observe the growth checks in scales.

Material and methods:

Specimens were collected from the trawlers operating from Mandapam and Rameswaram. Scales of 220 specimens of various size groups were examined for growth checks. The scales of fresh specimens were removed with the aid of a fine forceps from above pectoral axilla, washed in water to remove mucus and attached particles and examined under a microscope.

Otoliths of 180 fresh specimens were examined for growth checks after noting the total length weight, sex, locality and date of collection. Otoliths were removed by sliting open the postorbital region with the help of a sharp scalpel.

Otoliths were washed in water and dried. They were grounded on a carborundum stone to make them thin. Care was taken s that outer edges were not broken. The ground otoliths were kept in Creooste for a fortnight and then washed in Xylol and examined in reflected light. Relation between total length and otolith length was also found out by using the formula (9) and

$$Y = bX \quad .. \quad .. \quad (22)$$

Fresh specimens were boiled in water and opercular bones and vertebrae were removed, dried and examined for growth checks in reflected light with the aid of low power binocular microscope.

For the study of length frequency distribution total length of 12,471 fresh specimens were measured ffom Mandapam and Rameswaram. As the sexes could not be distinguished by the external characters, they were pooled together. The data was pooled for each month and the frequency distribution was tabulated for each class interval. Percentage of each length group was calculated and histograms were drawn taking length groups along 'X' axis and the percentages in 'Y' axis.

Probability paper was used for dissecting length frequency data. Total length of 8,688 and 3,883 specimens were taken for calculating the cumulative percentages. The cumulative percentages were plotted on an arithmetic probability paper and the modes were determined as described by Cassie (1954).

Age-length and age-weight data were fitted to von Bertalanffy's and Gompertz equations. Correlation coefficient 'r' of both equations were also determined to find out which of the two equation gave a better fit to the data.

Results

Examination of the hard parts:

Scales:- Scales were examined for detecting growth checks in them. It was not possible to detect any growth checks or growth rings on the scales. Hence it was not found to be useful for the age determination in *P. macrophthalmus* The relation of total length and scales length was found to be linear: Y = .2908 + .0248 X

Otoliths:- Otoliths of *P. macrophthalmus* are thick and opaque. The Central portion is more solid than the peripheral portion. The inner lateral side is granular and outer lateral side is smooth with an anterior depression and a shallow marginal and posterior depression.

180 otoliths belonging to all size groups were examined and concentric rings were found only in 12 otoliths. The rest of the otoliths were without any 'rings'. But the 'rings' were not correlated to the size of the fishes. Fishes of total length 134 mm had 3'rings' whereas 174 mm fishes had only one 'ring'. Similarly otoliths of larger length groups were found

to have less number of 'rings' and the otoliths of smaller length groups had more. Otoliths of same length groups also found to have different number of 'rings'. Due to these reasons, the 'rings' in the otoliths were not considered to be the indicators of age.

Relation between the total length and the otolith length:

Various workers have established relationship between the length of fish ~~length~~ and the length of otolith. This study is useful for the age determination and for the back calculation if one of the values is known.

By using the method of least squares, the total length and otolith length were fitted with two regression lines using the formulae (9) and (22).

The regression line drawn using the formula (9) intercepted the 'Y' axis whereas that drawn by using (22) passed through the origin. After calculating the values of the constants 'a' & 'b' of the formual (9) became

$$Y = 1.0971 + .0359\ X \quad .. \qquad (23)$$

and the formula (22) became

$$Y = .0272\ X \quad .. \qquad (24)$$

To find out which of the two equation gaves a better fit to the (Pl.XVI, Fig.3) data points, sum of the squares of the residuals were calculated for both the equations by the formula

$$U = \Sigma y^2 - a\ \Sigma y - b\ \Sigma xy - c\ \Sigma xy^2 \qquad (25)$$

while simplifying the above equation it became

$$U = \Sigma y^2 - a\ \Sigma xy \quad .. \qquad (26)$$

for the equation (22)

$$U = \Sigma y^2 - a\ \Sigma y - b\ \Sigma xy \quad .. \qquad (27)$$

By using the equation (26) and (27) for the formula (9) and (22) respectively, the sum of the squares of residuals were calculated and found to be 421 for (9) and 881 for (22). From these values it was evident that the formula (9) gave better fit to the data points than the formula (22). These results agreed with the observations of earlier workers like James (op.cit.) in B. intermedius.

Opercular bones and vertebrae:

The opercular bones showed no rings or growth checks. Hence they were not useful for the age studies. Similarly vertebrae were also examined which again showed no rings or growth checks. From the above observations it seems that the hard parts of Pennahia macrophthalmus are not useful for the determination of age.

Growth in length:

Length frequency method:- Petersen (1894) observed that the length the frequency distribution of samples from fish catches often showed several modes and inferred that these modes represented year classes. He showed that these modes progressed towards larger sizes with seasons and that a year later the first mode would reach the point occupied by the second mode. The draw backs of this method was that the rate of growth in length decreased with increasing age so that the overlap was greater in larger size groups. Hence it was more suitable for the younger fishes of the stock. However ~~it was~~ as good results were obtained by using this method, it was employed in age and growth studies of many fishes. Further this method is based on the assumption that the individuals of the same age group in a population of fishes are more or less normally distributed. Length frequency distribution might represent multimodal curve depending on the spawning periodicity of the fish. If there was one or two specific spawning seasons, the length frequency distribution generally presented a multimodal curve which could be dissected into several normal curves. By using this method the early year classes which showed more growth could be easily detected but with the advance in age which resulted in slow growth rate, the modes might overlap thereby making difficult to discern the modes. Moreover in fishes with prolonged breeding season, this method becomes more difficult. Inspite of the limitations the length frequency method has been used invariably by most of the workers who study the age and growth in fishes.

From the histograms (Plate XV, Fig.1) a mode can be observed in July, 1968 at 52 mm. It can be traced up to December at 97 mm registering 45 mm growth during 5 months.

Another mode can be seen at 117 mm in June shifting to 132 mm in August showing 15 mm growth in two months. In June a mode is seen at 137 mm becoming 162 mm in October recording 25 mm growth in four months. In May also another mode is seen at 137 mm progressing to 157 mmduring 3 months registering a growth of 7 mm per month. Another mode is seen in January at 152 mm and can be traced upto 177 mm showing a growth of 25 mm for four months, i.e. about 6 mm per month.

Similarly a few more modes can be traced during 1969 and their progression are also followed. In January, 1969 two modes are seen at 107 mm and 147 mm becoming 132 mm and 167 mm respectively in March and April. Similarly three more modes are observed in June at 117 mm, 132 mm and 147 mm becoming 162 mm in December, October and September showing a growth of 7 mm, 7 mm and 5 mm per month respectively. Another mode can be seen in September at 112 mm shifting to 142 mm in December registering 30 mm growth during 3 months. In October another mode can be seen at 102 mm progressing to 122 mm showing 10 mm growth per month. In November two modes can be seen at 87 mm and 97 mm shifting 97 mm and 112 mm respectively in December registering 10 mm and 15 mm growth per month.

From the above observations it is seen that the fishes grow about 10 mm per month in average during its first year, about 5 mm per month during its second year and about 2.0 mm in its third year. The progression of modal positions for the years 1968 and 1969 are given in the Tables 88-90.

From the study of its maturity stages based on the ova diameter, March and April appeared to be the peak spawning season. Juveniles of length group 32-54 mm appeared in the shore-seine catches during late July 1968. These juveniles might have been recruited from the March-April apwning.

From the above observation it could be seen that the fishes attained 132 mm at the end of 12 months, 195 mm in 24 months and 207 mm in 30 months (Table 91).

Due to the prolonged breeding season of the species the length frequency curve was of multimodal nature and presented some difficulty in tracing the age. However, such a type of breeding is seen in many fishes expecially of the tropics.

2. Probability plot method:

As mentioned earlier the length frequency distribution of *P. macrophthalmus* is a polymodal type and it is disected into normal curves by using probability plot method of Cassie (1954). This method was described earlier by Buchanan-Wallaston and Hodgson (1929) and Harding (1949). It was extended to fishery biology by Cassie (*op.cit.*).

Three modes were observed during the year 1968 at 56 mm 130 mm and 198 mm representing 0 - year group, first year and second year respectively (Pl.XVI, fig.1). After second year it was not possible to disect the curve. In 1969 (Fig.2) modes were seen at 85 mm, 132 mm and 195 mm representing 0 - year one year and second year respectively. To have a comprehensive idea, the data for 1968 and 1969 were pooled and the probability plot was drawn (Pl.XVI, Fig.3). Here also modes at 52 mm, 130 mm and 195 mm were obtained representing a 0 - year group, first and second years respectively. Beyond two years the age could not be traced. This might be due to the lesser rate of growth of the fishes after two years.

However, there was a good agreement between the growth determined by Petersen method and by probability chart.

3. Fitting of growth curve using von Bertalanffy's equation:

The biological growth curves are useful to compare the difference in growth phenomena and to conduct tests of these differences; to describe the changes in growth phenomena under varying conditions of environment, heredity and to describe the ideal growth phenomena that is expected to be typical (Riffenberg, 1960). Beverton and Holt (1957) developed a model for the dynamics of a exploited fish population, based on the growth curve of von Bertalanffy. According to von Bertalanffy (1938, 1949 and 1957) the growth of a fish could be adequately expressed by an exponential equation based on the general physiological principle. This equation has the form

$$l_t = L_\infty \left\{ 1 - e^{-k\,(t - t_o)} \right\} \quad .. \qquad (28)$$

where l_t is the length at any time 't', L_∞ is the asymptotic or the maximum length that a fish can theoretically reach, 'e' is the base of Neperian logarithm, 'k' the slope or the coefficient or catabolism, 't' the age of the fish and the 't_0' the theoretical age at which 'l_t' is zero.

This equation had been fitted successfully for the age-length data of many Indian species (Pantulu, 1961 and 1962; Pantulu and Singh, 1962; Nayak, 1965 and Qasim and Bhatt, 1966).

The growth parameters could be determined by arithmetic and graphic methods.

1. Arithmetic method:

von Bertalanffy's equation can be rewritten as

$$l_{t+1} = L_\infty(1-e^{-k}) + l_t \quad .. \quad (29)$$

which is a linear equation in terms of l_t and l_{t+1} and used by Bagenal (1955 a & b) in his study of the growth of long rough.

This is same as

$$l_{t+1} = a + bl_t \quad .. \quad (30)$$

where $a = L_\infty(1 - e^{-k})$ and $b = e^{-k}$

By using the method of least squares (Snedecor, 1955) the values for L_∞ and e^{-k} could be solved for the following values of l_{t+1} and l_t of the age-length data of Pennahia macrophthalmus.

Age (3 months	l_{t+1} (mm)	l_t (mm)
1	87	52
2	112	87
3	132	112
4	152	132
5	172	152
6	185	172
7	195	185
8	202	195
9	207	202

The estimated values of 'b' and 'a' are, b = 0.8211 = e^{-k} and a = 42.84. From the values of 'b', the values for 'k' can be found out as given below:

$$K = \log_e \frac{1}{e^{-k}} = \log_e \frac{1}{0.8211}$$

$$= \log_e 1.2178 = 0.1989$$

substituting the values of e^{-k} and 'a' in the equation,

$$a = L_\infty(1-e^{k}), \text{ we get}$$

$$42.84 = L_\infty(1-0.8211)$$

$$\text{Therefore } L_\infty = \frac{42.84}{0.1789} = 239.46 \text{ mm}$$

The formula (28) can be rewritten as:

$$-t_o = \frac{1}{k}\left\{ \log_e L_\infty - \log_e (L_\infty - L_t) \right\}^{-t} \quad .. \quad .. \quad (31)$$

Applying the above equation, the average values of 't_o' was calculated for different ages and was found to be 0.2679 for the species (Table 92).

Hence the von Bertalanffy's equation becomes

$$l_t = 239.46 \left\{ 1-e^{-0.1989\,(t - 0.2679)} \right\} \quad .. \quad (32)$$

ii. Graphical method:

Walford (1946) obtained the growth parameter L_∞ (asymptotic length) by plotting L_t against L_{t+1}. By this method L_∞ could be obtained which was the point of interception of the growth line by the bisector. From(Pl.XVI, Fig.4) L_∞ was found to be 240 mm. The slope of the growth line was equal to e^{-k} of the equation (28) from which the value of 'k' was found to be 0.1971.

't_o' also could be found out by plotting $\log_e (L_\infty - l_t)$ against the corresponding ages. When plotted, a straight line was obtained whose Y intercept was equal to $\log_e (L_\infty - k^{t_o})$. The value obtained was 5.43 (Pl.XVI, fig.5).

$$t_o = \frac{5.43 - 5.48}{0.1971} = -0.2536$$

Then the formula can be written as 240 $\left\{1-e^{-0.1971\,(t-0.2536)}\right\}$ which is almost the same as (32) derived by the theoretical method.

Using the equation (28) the theoretical values for length for a given age of Pennahia macrophthalmus were obtained as in the Table 92. It may be observed that a more or less a good fit is obtained for the curve drawn by using observed length-age data (Pl.XVI, fig.4)

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4. Estimation of growth parameters by Gompertz equation.

According to Bagenal (1955b), of the commoner growth equations the most appropriate would appear to be Gompertz equation. The Gompertz growth function can be expressed as

$$l_t = ab^{c^{(t+d)}} \quad .. \quad (33)$$

where l_t the length at time 't', 'a' the asymptotic length 'b' and 'c' the constants 't' the time in 3 months and 'd' the number of units by which the origin of the curve obtained from the estimates based on arbitrary designation of age had to be shifted to pass satisfactorily through the data points.

Bagenal (1955b) found that the Gompertz equation provided better fit to the growth data of long rough dab (Hippoglossoides ~~XXXXX~~ platessoides) than the von Bertalanffy's growth equation. Though Moore (1951), Riffenburg (1960) and Pantulu (1963) obtained good fit for the growth data of yellow fin tuna and Osteogeneiosus militaris respectively by using Gompertz equation, Qasim and Bhatt (1966), found that von Bertalanffy's equation provided better fit for their data.

Hence the data of growth parameters of Pennahia macrophthalmus was fitted to Gompertz growth equation (33) to find out whether it gave a better fit than von Bertalanffy's equation.

Though in Gompertz equation the estimation of the parameters were arbitrary, Riffenburgh (1960) had suggested many methods for the determination of the growth parameters. In the present study the 'short method' described by Riffenburgh (op.cit.) was followed.

In this method a set of triplets Yi, Yi+k having the properties k = 2j were obtained and one was chosen randomly. This triplet contained the data points (2, 87), 5, 152), (8, 195). Based on this triplets the parameters for (33) 'b', 'c' and 'a' were estimated. On inspection it had been observed that the curve obtained from the estimates had its origin translated 0.2 units to the right for it to pass satisfactorily through the data points. Thus '0.2' was the estimate for 'd'.

The parameters 'c', 'b' and 'a' were estimated as below: The triplets taken were (2.87),(5,152) and (8, 195)

$$87 = ab^{c^{2.2}} \quad .. \quad .. \quad (34)$$

$$152 = ab^{c^{5.2}} \quad .. \quad .. \quad (35)$$

$$195 = ab^{c^{8.2}} \quad .. \quad .. \quad (36)$$

$$\frac{195}{152} = b^{c^{8.2}} - c^{5.2} \quad .. \quad .. \quad (37)$$

$$b^{c^{3}(c^{5.2} - c^{2.2})} \quad .. \quad .. \quad (38)$$

$$\frac{152}{87} = b^{(c^{5.2} - c^{2.2})} \quad .. \quad .. \quad (39)$$

Taking log values of (38) and (39) and dividing

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$$\frac{\log \frac{195}{152}}{\log \frac{152}{87}} = \frac{c^3 (c^{5.2} - c^{2.2}) \log b}{(c^{5.2} - c^{2.2}) \log b}$$

$$c^3 = \frac{\log 1.282}{\log 1.747} = \frac{0.1079}{0.2422} = c = 0.7638$$

$\frac{36}{35}$ gives $\frac{195}{152} = b^{(c^{8.2} - c^{5.2})}$

$$\log b = \frac{\log \frac{195}{152}}{(c^{8.2} - c^{5.2})} = \frac{\log 1.282}{(0.7638)^{8.2} - (0.7638)^{5.2}}$$

$$= \frac{0.1079}{0.1098 - 0.2463} = \frac{0.1079}{-0.1365} = \bar{1}.2093$$

$$b = 0.1619$$

Adding (34), (35), (36)

$$434 = a \left\{ b^{c^{2.2}} + b^{c^{5.2}} + b^{c^{8.2}} \right\}$$

$$\log 434 = \log a + \log \left\{ b^{c^{2.2}} + b^{c^{5.2}} + b^{c^{8.2}} \right\}$$

$$\log a = \log 434 - \log \left\{ \text{antilog } (c^{2.2} \log b) + \text{antilog } (c^{5.2} \log b) + \text{antilog } (c^{8.2} \log b \right\}$$

$$= 2.6375 - \log \left\{ \text{antilog } (0.7638^{2.2} \times \bar{1}.2093) + \text{antilog } (.7638^{5.2} \times \bar{1}.2093 + \text{antilog } (.7638^{8.2} \times \bar{1}.2092) \right\}$$

$$= 2.6375 - \log \left\{ \text{antilog } (\bar{1}.5629) + \text{antilog } (\bar{1}.8052) + \text{antilog } (\bar{1}.9132) \right\}$$

$$= 2.6375 - \log (0.3656 + 0.6386 + 0.8189)$$

$$= 2.6375 - \log 1.8231 - 2.6375 - 0.2608 - 2.3767$$

$\log a = 2.3767;\ a = 238.1$

The estimates of 'c', 'b' and 'a' were found to be 0.7638, 0.1619 and 238.1 respectively and Gompertz growth curve was estimated to be

$$l_t = 238.1\ (.1619)^{(0.7638)^{(t\ +\ .2)}} \quad .. \quad (40)$$

By using the formula (40) calculated length for different ages were estimated and tabulated (Table 94). The calculated length were plotted against the age. It was obvious that the theoretical lengths obtained from the formula (40) deviated from the observed lengths over a wider limits than those calculated from the formula (32), (Pl.XVI, Fig.6).

To test which of the two equations (32) or (40) would fit better to the observed data, the correlation coefficient 'r' of Y = (observed data) and X = (calculated data) for (32) and Y = (log observed data) and X = (log calculated data) for (40) were determined. These were found to be .9991 for the equation (32) and 0.9940 for the equation (40).

It is obvious from the above values of correlation coefficient 'r' that the von Bertalanffy's growth equation explained the growth parameters of Pennahia macrophthalmus better than Gompertz growth equation.

5. Growth in weight:

From the commercial fishery point of view, the weight of the fish is more important as it is directly proportional to the total catch. From the Pl.XVII, Figs.1 and 2, it was seen that though the increment in length was more during the first year, the increase in weight was more during the second year. Of the total weight of 128 gm attained during the 2½ years of its life span, 30 gm. (23.4%) was attained during the first year, 75 gm (58.8%) during the second year and 23 gm (17.8%) during the first six months of the third year. But of the total length 207 mm reached during the period 2½ years, 132 mm (63.8%) was attained during the first year, 63 mm (30.4%) during the second year and 12 mm (5.8%) during the first 6 months of the third year.

i. <u>Fitting of age-weight data by von Bertalanffy's equation</u>:

To express the growth in weight of a fish, an equation which was analogous to that of von Bertalanffy's growth equation having the form

$$W_t = W_\infty \left\{ 1-e^{-k\,(t-t_o)} \right\}^3 \quad .. \quad .. \quad (41)$$

where W_t the weight at time 't', W_∞ the asymptotic weight, 'e' the base of Neperian logarith, 'k' the slope or the coefficient of catabolism, 't' the age of fish and 't_o' the theoretical age at which W_t was zero, was followed as suggested by Ricker (1958), Cushing (1968) and Allen (1969). More or less similar equations were employed by Ricker (1958) and Qasim and Bhatt (1966). When plotted, a straight line was obtained whose Y - intercept was equal to $\log_e W_\infty^{1/3} - k^{t_o}$. The value obtained was 1.615 (Pl.XVII, Fig.3)

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Hence $t_o = \frac{1.616 - 1.673}{0.2093} = -0.2771$

The formula (41) could be written as

$$W_t = 180 \left\{ 1-2^{-0.2093\ (t + 0.2771)} \right\}^3 \quad .. \qquad (42)$$

Theoretical values estimated by the formula (42) were tabulated (Table 95). The data for the observed growth in weight and calculated growth weight and was also plotted. It was evident from the curve (Pl.XVII, Fig.5) that von Bertalanffy's equation adequately explained the growth in weight of Pennahia macrophthalmus. However the correlation coefficient ' ' was calculated for the observed and calculated data, and it was found to be 0.9978. It should that there was good correlation between the calculated and observed values.

2. Fitting of age-weight data by Gompertz equation:

As in the length-age studies, Gompertz equation (33) was fitted with weight-age data. The triplets (2, 8.05), (5, 47.7) and (8, 105.70) were taken and various parameters 'c', 'b' and 'a' were calculated. Values for 'c', 'b' and 'a' were found to be 0.7643, 0.0029 and 200.6 respectively. The Gompertz curve had the form:

$$Y = (200.6)\ (0.0029)^{\ 0.7643^{(t + 0.2)}} \quad .. \qquad (43)$$

To test which of the two equations (42) or (43) would fit better to the data the correlation coefficient 'r' of Y = the observed data and X the calculated data for (42) and Y = log observed data and X = log calculated data for (43) were calculated. There was found to be 0.9976 for the equation (43) and 0.9978 for the equation (42). From the values of 'r' it could be inferred that the von Bertalanffy's equation gave better fit to the data.

The equation (41) was fitted with the weight-age data of *Pennahia macrophthalmus* to find out its utility in explaining its growth by weight.

From the length-weight regression line for the two years data, the weight (W_t) for the corresponding weight after the period t + 1 (W_{t+1}) was found as given below:

't' (3 months)	W_t (gm)	W_{t+1} (gm)
1	1.5	8.0
2	8.0	18.0
3	18.0	30.4
4	30.4	47.7
5	47.7	70.8
6	70.8	89.4
7	89.4	105.7
8	105.7	118.4
9	118.4	127.9

The above data was used for extracting the estimates for W_∞ and e^{-k} by the graphical method of Walford (1946) plot as explained for the determination of L_∞ and e^{-k} using age-length data. W_∞ was found to be 180 gms and e^{-k} = 0.8111 (Pl.XVII, Fig.5). From the values of e^{-k}, 'k' could be found out as follows:

$$e^{-k} = 0.8111$$

$$-k \log_e = \log_e (0.8111)$$

$$-k \log_{10} (0.8111) \times 2.3026$$

$$-k = 0.0909 \times 2.3026 = 0.2093$$

The value of 't_o' could be determined by plotting $\log_e (W_\infty^{1/3} - W_t^{1/3})$ against 't' as per the equation:

$$\log_e (W_\infty^{1/3} - W_t^{1/3}) \quad \log_e W_\infty^{1/3} + k_{to} \; 1 - k_t \; t \; .. \qquad (44)$$

From the values of correlation coefficient (r), it could be seen that the growth parameter by weight was better explained by von Bertalanffy's equation than by Gompertz equation. However as the correlation coefficient for both the equations were 0.9978 and 0.9976, they are more or less equally good in explaining the growth parameters of *Pennahia macrophthalmus*.

A logistic S-shaped curve was obtained by using the equation for growth in weight (Pl.XVII, Fig.6). This explained slow rate of increase to start with leading to faster rate of growth and flattening of to an asymptote eventually as the age increased. Such growth patterns have been observed in some other fishes also (Pantulu, 1961; Qasim and Bhatt, 1966).

Discussion:

Karandikar and Takur (1951), Kutty (1961) and Bhatt et al (1967) studied the age and growth of Otolithoides brunneus; Srinivasa Rao (1962) and Bhatt et al (1967), observed the age and growth of Pseudosciaena diacanthus. But information on the age and growth of other sciaenids was quite meagre except for the observations of Savant (1964) on Johnius dussumieri of Bombay coast.

Srinivasa Rao (1962) found growth rings on the scales and otoliths of P. diacanthus and attributed to the availability food, strain due to spawning activity and the hydrological conditions.

Kutty (1961) also found growth checks in the scales and otoliths of Otolithoides brunneus and observed that availability of food and hydrobiological conditions may be the causative factors for the formation of growth checks. He traced six rings in otoliths and 12 rings in the scales from specimens of size 5 to 155 cm. The occurrence of more number of rings in otoliths than in scales may be an indication that otoliths were more senstive than the scales for the recording changes in the condition of fish (Saeterdal, 1953). Kotthaus (1958) also found formation of 2-4 rings in the otoliths of Clupea pilchards. However, Kutty,(Op.cit.) observed that scales were more reliable than otoliths as age indicator in P. braunneus. Bhatt et al (1967) also used scales as an indicator of age in P. diacanthus and observed 6 to 11 age groups. But though otoliths, scales and opercular bones of P. macrophthalmus were examined carefully they were found to be not useful for age determination as the regularity of the occurrence of these 'rings' were not corresponding to the length of fish.

Analysis of the length frequency data by Petersen's method was one of the commonly followed methods for tracing the year class. In the present study data for 1968 and 1969 were analysed. It was observed that the fishes attained 132 mm at the end of 12 months, 193 mm in 24 months and 207 mm in 30 months. It was evident that the rate of growth was high during the first year (Pl.XVII, Fig.1)

Harding (1949) used the probability plot for dissecting the length frequency curve. Using the method, the length frequency curve of P. macrophthalmus was dissected and three modes were found at 52 mm; 130 mm and 195 mm representing '0' year, first and second year groups respectively. Beyond two years, age could not be traced due to the lesser rate of growth. Results obtained by this method agreed with that of Petersen's method.

Jhingran (1959), Pantulu (1963), Singh and Rege (1968) and Jhingran (1972) also applied this method in Cirrhina mrigala, Osteogeneiosus militaris, Tachysurus sona and Setipinna phasa respectively.

Growth of P. macrophthalmus was described using the basic premise that growth rate (dw/dt) increased proportionately to weight raised to the fractional power (w^x). Kleiber (1947) suggested that food capacity, food intake and gain in weight in animals should be related to the 3/4 power of weight. Fry (1957) demostrated for rainbow trout that the rate of oxygen consumption increased in proportion to $W^x = 0.8$. Assuming that weight was proportional to l^3, then growth rate (weight) was proportional to $W^x = 0.8$ (Parker and Larkin, 1959).

The growth equation of von Bertalanffy's was equivalent to the self inhibiting 'growth' equation of Brody (1945) and the graphic transformation presented by Walford (1946). According to von Bertalanffy the growth is the net result of an apex system of supply and demand of resources which can be metabolised. Since material must enter the organism through a surface and maintenance demand was proportional to mass, given isometric growth the organism would eventually reach a size where supply and maintenance demand were in equilibrium.

von Bertalanffy's basic equation was $dw/dt = HS - kw$ where S denotes surface of limiting membrane 'w' the mass and 'H' and 'k' are proportion constants when the growth was isometric and the density was a constant and a surface is proportional to the square of the length and the mass is proportional to the length cubed. This showed growth as a process in which first difference of a length series l_1, l_2, l_3 etc., decreased by a constant percentage, i.e. on an arithmetic plot of l_{t+1} against l_t, fall on a straight line which intercepts a 45° diagonal with origin 0, 0. There were certain assumption inherent in von Bertalanffy's equation. It placed emphasis on the two third rule or 'surface rule' of Brody (1945) which stated that metabolism as measured by rate of oxygen consumption increased as the two third power of weight. Prosser (1952) and others had indicated the metabolic rate increased as the 0.73 power of weight. However, Kleiber (1947) stated many of the inadequacies of the 'surface rule' and cautioned against assumption of any strict proportéinality between 'true' body surface and metabolic rate.

Szarski et al (1956) also found absorption areas of the gut of Abramis brama to grow by means of infolding approximately in proportion to the weight.

The apparent fit of a von Bertalanffy's equation or Walford line to growth data may in some cases be found as a result of the method of sampling or combining data. This had been showed by Parker and Larkin (1959) in Chinook. They used two treatments considering the life history group separately and only fish captured in fourth growth year. These two methods of treatment led to diverse conclusions. By considering each life history group separately growth was seen to approach parallelism with the 45° diagonal. The second treatment depicted growth rate as gradually decreasing and formed an approximately linear plot which would intercept in 45° diogonal. The later treatment depicted growth as von Bertalanffy's equation. But it led to under estimation when predicting future increment to the stock from growth. However if each component group was weighted according to its actual abundance in population, ~~and~~ as Parker and Larkin (*op.cit.*) stated that von Bertalanffy's equation could be used without over simplification and under estimating of growth of a hypothetical average fish in the entire population.

The age and length data of *P. macrophthalmus* was fitted with Bertalanffy's and Gompertz equations as done by Pantulu (1961) and Qasim and Bhatt (1966). Growth parameters for Bertalanffy's equations was determined by arithmetic and graphic methods and the results were found to be agreeing.

The information on increment in weight was more important as it was directly related to the quantity of fish landed. Hence the age-weight data was fitted to Bertalanffy and Gompertz equations. Both the equations adequately explained the growth parameters of *P. macrophathalmus*.

[redacted]

TABLE 88

Progression of modal positions of *Pennahia macrophthalmus* during 1968 and 1969

	52	72	77	82	87	92	97	102	107	112	117	122	127	132	137	142	147	152	157	162	167	172	177	182	187	192	197
Jan.	-	-	-	-	-	-	-	102	-	112	-	-	-	-	-	142	-	152	-	-	-	-	-	-	-	-	-
Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar.	-	-	-	-	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	172	-	-	-	-	-
Apr.	-	-	-	-	-	-	-	-	-	-	-	-	-	132	-	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	97	-	-	112	-	-	-	-	137	-	-	-	-	-	-	-	177	-	-	-	-
June	-	-	-	-	-	-	-	102	-	-	117	-	127	-	137	142	-	-	-	-	-	-	-	-	-	-	-
July	52	-	-	-	87	-	-	-	-	-	117	-	-	-	-	-	-	152	-	-	-	-	-	-	-	-	197
Aug.	-	-	-	-	-	-	97	-	-	-	117	-	-	132	-	-	-	-	-	-	-	-	-	-	-	-	-
Sep.	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-	147	-	-	-	-	172	-	-	-	-	-
Oct.	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-	-	152	-	162	-	-	177	-	-	-	-
Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec.	-	-	-	-	-	-	97	-	-	-	-	-	-	-	-	142	-	-	-	-	-	172	-	-	-	-	-
Jan.	-	-	-	-	-	-	-	-	107	-	-	-	-	-	-	-	147	-	157	-	-	.	177	-	-	-	-
Feb.	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-	-	152	-	-	-	-	177	-	-	-	-
Mar.	-	-	-	-	-	-	-	-	-	-	-	-	-	132	-	-	-	-	157	-	-	-	-	-	187	-	-
Apr.	-	-	-	-	-	-	-	-	-	-	-	-	127	-	-	-	-	152	-	-	167	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	137	-	-	-	-	162	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-	117	-	-	132	-	-	147	-	-	-	-	-	177	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-	-	152	-	-	-	-	-	-	187	-	-
Aug.	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	142	-	-	-	-	-	-	177	-	-	192	-
Sep.	-	-	-	-	-	-	-	-	-	112	-	-	-	-	137	-	-	-	-	-	-	-	177	-	-	-	-
Oct.	-	-	-	-	-	-	-	102	-	-	-	-	-	-	-	142	-	-	-	162	-	-	-	-	-	-	-
Nov.	-	-	-	-	87	-	97	-	-	112	-	122	-	132	-	-	-	-	-	-	-	-	-	-	-	192	-
Dec.	-	-	-	-	-	-	97	-	-	112	-	122	-	-	-	142	-	152	-	162	-	-	-	-	-	-	-

TABLE 89

Length frequency of data of <u>Pennahia macrophthalmus</u> for the year 1968

Size groups	Jan. No.	%	Feb. No	%	Mar. No	%	Apr. No	%	May No	%	June No	%	July No	%	Aug. No	%	Sep. No	%	Oct. No	%	Nov. No	%	Dec. No	%	Total
35-39													2	.2											2
40-44																									
45-49													3	.3											3
50-54													12	2											12
55-59																									
60-64																									
65-69																									
70-74																									
75-79			1	.1			1	.1	2	.2	5	.8	6	.5			1	.1							16
80-84							1	.1	5	.5	5	.9	13	1	1	.2							1	.7	27
85-89					1	.1	1	.1	6	.6	10	2	23	2	1	.2	1	.1	1	.2					44
90-94	1	.3	2	.2			2	.1	7	.7	12	2	19	2	7	1	9	9	1	.2			1	.7	61
95-99	1	.3	3	.3	1	.1	4	.3	12	1	23	4	29	3	20	4	17	2	3	.6			4	3	117
100-104	6	2	15	2	4	.3	11	.9	16	2	29	5	75	7	19	3	23	2	10	2			3	2	211
105-109	4	1	25	3	22	2	19	1	26	3	23	3	89	8	93	6	59	6	19	3			2	1	321
110-114	13	4	31	3	47	4	52	4	36	4	42	7	103	9	47	9	84	8	27	5			2	1	484
115-119	10	3	50	6	64	5	84	7	38	4	61	10	115	10	63	11	129	13	51	10			7	5	672
120-124	30	.4	81	10	121	10	141	11	61	6	55	9	111	10	60	11	148	15	71	13			6	4	885
125-129	33	10	106	12	160	12	187	15	76	8	52	9	107	9	45	8	128	13	70	13			10	7	974
130-134	30	9	113	12	218	17	189	13	156	15	38	6	83	7	55	10	81	9	60	11			11	8	1034
135-139	30	9	81	9	196	15	161	12	172	17	54	8	61	5	49	9	53	5	33	6			13	10	903
140-144	47	15	74	8	122	10	120	10	121	11	52	9	58	5	33	6	44	5	30	6			20	15	721
145-149	25	8	73	8	110	9	83	7	81	8	44	7	67	6	27	5	42	4	23	4			19	14	594
150-154	30	9	86	10	73	6	73	6	75	8	44	7	69	6	26	5	35	4	25	5			19	14	555
155-159	15	5	57	7	49	4	48	4	38	4	37	6	39	3	32	6	34	3	23	4			7	5	379
160-164	19	6	36	4	37	3	29	2	30	3	18	3	21	2	15	3	27	3	26	5			5	4	263
165-169	8	3	15	2	13	1	16	1	13	1	13	2	29	2	11	2	12	1	20	4			2	1	144
170-174	3	.9	7	.8	12	.9	11	.9	9	.9	11	2	6	5	3	.5	21	2	11	2			3	2	97
175-179	4	1	6	.7	4	.4	7	.6	14	1	5	.8	8	.7	1	.2	6	.7	14	3					69
180-184	7	2	7	.8	3	.3	3	.3	8	.3	3	.5	2	.2	2	.4	9	1	1	.2					45
185-189	2	.6	2	.2	3	.3	8	.6	6	.6	1	.1	1	.1					3	.6					26
190-194			1	.1			5	.4	2	.2			1	.1	1	.2	2	.2	2	.4					14
195-199	1	.3	1	.1			2	.1	2	.2					1	.2									7
200-204	1	.3			2	.1			1	.1							2	.2	1	.2					7
205-209													1	.1											1

TABLE 90

Length frequency data of Pennahia macrophthalmus for the year 1969

Size groups	Jan. No	Jan. %	Feb. No	Feb. %	Mar. No	Mar. %	Apr. No	Apr. %	May No	May %	June No	June %	July No	July %	Aug. No	Aug. %	Sep. No	Sep. %	Oct. No	Oct. %	Nov. No	Nov. %	Dec. No	Dec. %	Total
70-74	1	.2													1	.1			1	.4					3
75-79															2	.2	1	.3			1	.6			4
80-84															2	.2	2	.5	1	.4					5
85-89													3	.5	3	.4	2	.5	1	.4	3	2	1	.8	13
90-94	2	.5									2	.8	2	.3	2	.3	3	.8	1	.4	1	.6	2	2	15
95-99	2	.6									8	3	8	1	6	.8	2	.5	3	1	5	3	8	6	42
100-104	4	1			4	.6					9	4	16	2	11	1	5	1	6	2	1	.6	3	2	59
105-109	8	2	3	.9	5	.8					15	6	31	5	26	4	9	3	6	2	7	4	6	5	116
110-114	6	1	5	1	10	2					20	8	49	8	60	8	21	6	19	7	18	10	13	10	221
115-119	10	2	10	3	18	3	2	10			44	17	63	10	81	11	18	5	24	9	11	6	10	8	291
120-124	13	3	14	4	29	5					26	10	77	11	100	14	39	10	39	14	22	13	13	10	372
125-129	17	4	13	4	40	6	2	10			20	8	58	9	82	12	45	13	42	16	18	11	10	8	347
130-134	31	8	21	7	44	7			1	8	24	9	42	6	68	10	45	13	33	12	22	13	10	8	341
135-139	38	9	27	8	36	6	1	5	3	25.	11	4	32	5	35	5	36	10	22	8	20	12	10	8	271
140-144	49	12	31	10	50	8			3	25	17	7	38	6	46	6	15	4	21	8	11	6	11	9	292
145-149	56	14	39	13	64	11	4	20	1	8	21	8	40	6	29	4	19	5	15	6	10	6	7	6	308
150-154	48	12	41	12	83	14	4	20			112	94	48	7	45	7	18	5	4	2	5	3	8	6	315
155-159	48	12	37	12	86	15	1	5	1	8	8	3	45	8	35	5	22	6	7	3	6	3	3	2	299
160-164	32	8	37	12	42	7	1	5	1	8	8	3	35	6	30	4	25	7	8	4	1	6	7	5	227
165-169	10	2	17	5	35	6	3	15	1	8	5	2	26	4	14	2	10	3	5	2	1	.6	2	2	130
170-174	5	1	8	2	27	4	1	5			1	.4	16	2	12	2	8	2	3	1	2	1	1	.8	84
175-179	8	2	10	3	13	3	1	5	1	8	3	1	4	.6	14	2	7	2	2	7	3	1	1	.8	67
180-184	5	1	4	1	5	.8					1	.4	2	.3	5	.7	1	.3	1	.4	2	2			26
185-189					6	.9					2	.8	2	.3			2	.6	1	.4			1	.8	14
190-194	1	.2	1	.3	5	.8							1	.1	2	.3	1	.3			2	1			13
195-199	1	.2											3	.5	1	.1			1	.4	1	.6			7
200-204	1	.2																							1
205-209	1	.2																							1

TABLE 91

Fit of von Bertalanffy's equation to length at age for <u>Pennahia macrophthalmus</u>.

t (3 months)	$t-t_o$	$-k(t-t_o)$	$e^{-k(t-t_o)}$	$1-e^{-k(t-t_o)}$	$L_\infty\left\{1-e^{-k(t-t_o)}\right\}$	Observed length (mm)
1	1.2679	-2.2521	0.7788	0.2212	52.96	52.0
2.	2.2679	-0.4511	0.6376	0.3612	86.78	87.0
3.	3.2679	-0.6499	0.5220	0.4780	114.46	112.0
4.	4.2679	-0.8489	0.4274	0.5726	137.11	132.0
5.	5.2679	-1.0477	0.3499	0.6501	155.67	152.0
6.	6.2679	-1.2461	0.2865	0.7135	170.85	172.0
7.	7.2679	-1.4455	0.2345	0.7655	183.30	185.0
8.	8.2679	-1.6445	0.1939	0.8061	193.02	195.0
9.	9.2679	-1.8434	0.1588	0.8412	201.43	202.0
10.	10.2679	-2.0423	0.1300	0.8700	208.33	207.0

TABLE 92

Age-length data values of t_0 at different ages. (L_∞ = 239.46)

Age t (3 months)	Length l_t(mm)	$L_\infty - L_t$	$\log_e (L_\infty - l_t)$	t_0
1	52	187.46	5.2311	-0.2332
2.	87	152.46	5.0239	-0.2750
3.	112	127.46	4.8442	-0.1780
4.	132	107.46	4.6728	-0.0402
5.	152	87.46	4.4659	-0.0840
6.	172	67.46	4.2046	-0.3941
7.	185	54.46	3.9889	-0.4786
8.	195	44.46	3.7842	-0.5077
9.	202	37.46	3.6109	-0.3790
10.	207	32.46	3.4657	-0.1091
Average				-0.2679

TABLE 93

Observed rate of growth of Pennahia macrophthalmus for 1968 and 1969

Months	Period (month)	Length (mm)	Rate of growth per 3 months (mm)	Rate of growth per month (mm)
July	3	52	52	17.3
October	3	87	35	11.6
January	3	112	35	11.6
April	3	132	20	6.6
July	3	153	20	6.6
October	3	172	20	6.6
January	3	185	13	4.3
April	3	195	10	3.3
July	3	202	7	2.3
October	3	207	5	1.6

TABLE 94

Some age and length relationship for the *Pennahia macrophthalmus* obtained by the von Bertalanffy's and Gompertz's equations.

Age in 3 months	Length observed (mm)	Length by Bertalanffy's equation (mm)	Length by Gompertz's equation(mm)
1	52	52.96	63.7
2	87	86.78	87.0
3	112	114.46	110.4
4	132	137.11	132.3
5	152	155.67	152.0
6	172	170.85	169.0
7	185	183.30	183.2
8	195	193.02	195.0
9	202	201.43	204.4
10	207	208.33	211.9

TABLE 95

Observed and calculated values of age-weight data, by von Bertalanffy's equation and Gompertz' equations.

Age in 3 months	Observed weight (gm)	Calculated weight (von Bertalanffy's equation) (gm)	Calculated weight (Gompertz's equation) (gm)
1	1.56	2.37	2.98
2	8.05	9.97	8.04
3	18.00	22.28	17.15
4	30.46	37.60	30.63
5	47.74	53.42	47.69
6	70.82	70.07	66.91
7	89.39	85.84	86.66
8	105.70	100.22	105.60
9	118.40	113.00	122.80
10	127.90	124.11	137.90
		'r' = 0.9978	'r' = 0.9976

'r' = regression coefficient

VII. RACIAL STUDIES

Introduction:

Racial studies are made in fishes so as to identify the stocks. Whether the population of one area is part of the same stock of fish as that found along another region or an independent stock, is a question of considerable importance. If they belongs to the same stock, further fishing effort will merely add to the strain on the stock already exploited; if they are different stocks, they can be tapped as a virgin resource. Thus fishing on a homogeneous population will affect the population in other localities also. On the contrary if a species consists of different stocks or races, fishing at one locality will not have any effect on the other unfished part of the tock. Identification of stock or race is also important from the management point of view. Proper management of maximum sustainable yield requires that each stock or race be managed separately. If two or more stocks of fish are harvested by the same fishery, the total yield will be less than the combined yield of the individual stock because it is not possible to harvest each at its optimum level. For example, if a resource made up of two or more stocks, is being managed by imposing a catch quota, it is quite likely that one stock will be over fished while the other is underfished. Thus the maximum sustainable catch will be less than the total maximum sustainable yield of an individual race or stock.

Heincke (1898) defined race as a community of fish that spawned at certain place to which they repeatedly return. According to Berg (1948, 1953), a race is not a geographical unit but an elementary type, a stable form linked with species by transitional features. Morozov (1932) stated that races could be distinguished by morphological features, mean dimensions of the fish and by area of distribution. Vibert and Lagler (1961) viewed race as a local population distinguished by meristic features that were dependent on the environment. The races are ecological units whose range lie within the ranges of species and that they are distinguished by both morphological and biological features. Races consist of all groups and their features are hereditarily stable. The basic difference between the sub-species and race is at sub-species is always bound up with a definite section of the range of its species where as the habitat of ecological race is spread throghout the range of its species. (Lebedev, 1939) Stock is defined as a self reproducing inferaspecific biological grouping of fish smaller than race distinguished by biological features (growth rate, period of reproduction etc) and consisting of all age groups (Lebedev, op.cit.). It can be assumed that the smallest self reproducing population unit is the stock. However, he stated that within the species of fish infraspecific biological groupings smaller than race or stock do undoubtedly exist in nature. He called these groups as elementary fish populations which constituted other groups of the population such as stock or races.

Many methods are followed for the identification of the stock or race. One of the commonly used technique is based on the morphometric characters - measurements of body proportion and counts of meristic characters. Heincke (1898) was the first to subdivide a species (Clupea harengus) based on the variation in body proportions and meristic characters. Thompson (1917) and Hubbs (1925) analysed the morphometric characters of Pacific herring and established the existence of two distinct races in the British Columbia and San Franscisco Bay. Schaefer (1952, 1955) and Royce (1953) studied the morphometric characters of yellow fin tuna (Thunnus albacores) of tropical Pacific Ocean. While analysing races in Hilsa ilisha and Barbus species, Pillay (1951, 1957) used morphometric and meristic characters. James (1967) also studied the morphometric characters of the ribbon fish Eupleurogrammus intermedius of different localities along the east coast of India. Thomas (1969) analysed the mertistic and morphometric characters of the goat fish Upeneus tragula from Indian coast and Pacific Ocean.

Hart (1933), Clark (1947) and Parrish (1956) employed vertebral counts finrays in the racial investigation of the Pacific sardine and hake. Scott (1954) found differences not only in dorsal and anal fin-ray counts of yellow tail flounders from three fishery areas Atlantic coast; but also in body proportions otoliths, scales, growth rate, age at maturity and time of spawning. Bayagbona (1963) analysed the meristic characters of two species sciaenid fishes (Pseudotolithus spp.)

from Logos trawling grounds. Boulva (1972) studied the meristic and morphometric characters and the structure of otoliths to differentéiate the artic cod of Cambridge Bay.

Recently a number of new techniques have been developed for the facial studies of fishes. Suzuki et al (1958) presented evidences that albacore (Germo alalunga) population in Pacific an Indian Ocean differed with respect to blood type frequencies. Ridgway et al (1958) studied the races of sockeye salmon Oncorhynchus nerka by serological techniques. Sindermann and Mairs (1959) employed serological techniques to investigate races of Atlantic herring. The blood groups of Sardinops caerulea were studied by Sprague and Vrooman (1962) and they found that the northern and southern forms were reproductively isolated. Vrooman (1964) used serological methods and found three genetically distinct populations of Pacific sardines. Electrophoresis and serology were employed by Cushing (1964) in his investigations of detecting races in tunas. Farris (1957) reviewed the literature on the use of chromatography for the study of races. But this method could be useful only if the limits of individual variations had been determined. Tagging also was successfully employed in tunas to find out whether there was any mixing of the populations (Schaefer, 1958). Margolis et. al (1966) reported identification of races of sockeye salmon by tagging, parasitic infestation, scale characters, serology and morphology. Ahlstrom (1957) discussed the recent advances in the racial investigations of fishes.

Material and methods:

Fishes were collected from the trawl catches Mandapam, Madras, Kakinada, Waltair and Hong Kong. All the measurements were taken nearest to millimeter as described by Marr and Schaefer (1949). Total length was taken as an independant character and the characters like head length, eye diameter length of snout, length of pectoral fin, length of second anal spine were traced as dependent characters.

These characters were defined as

Head length: distance from tip of snout to posterior most free end of suboperclo.

Eye diameter: The greatest diameter between the free margin of eye.

Snout length: Distance between tip of upper jaw to anterior most point of eye.

Pectoral fin length: The distance from the insertion of the pectoral fin to the posterior tip of the fin.

Based on the principles of least squares, the formula $Y = a + bX$ where 'Y', the standard length and 'X' the total length and 'a' and 'b' the constants werefitted to standard length-total length data. Similarly regression lines were also fitted for head length, eye diameter, snout length, pectoral length and second anal spine in relation to total length (Table 96).

Analysis of covariance was used to test the difference between various characters of samples difference places at 5% level of probability (Table 97-103).

Analysis of morphometric characters:

Relationship between total length and standard length were found out. Total length in mm were plotted against standard lengths and the relationship was found to be linear. As the morphometric characters examined were not found to be significant at 5% level between sexes, the data for male and female were pooled. The regression formula $Y = a + bX$ was fitted to the data. The equation was found to be $Y = -7.6447 + 0.8546 X$. From the (Pl.XVIII, Fig.2) it could be observed that the points lie very close to the regression line indicating high degree of correlation between total length and standard length.

Head length:

The head lengths of the specimens from Mandapam were compared with that of Hong Kong and Madras; similarly the head lengths of specimens from Mandapam were also compared with that of Kakinada. It was found that this character was significant at 5% level within the samples from Mandapam, Hong Kong, Waltair, Madras and Kakinada; but though it was found to be significant at 5% level between the samples from Mandapam and Madras, the samples from Madras and Kakinada and Mandapam and Hong Kong were found to be non-significant at 5% level. Table 99). The regression lines from Mandapam, Hong Kong, Waltair, Madras and Kakinada were found to be as in the Fig.3. (Pl.XVIII).

Snout length

Snout lengths within the samples from the Mandapam, Hong Kong, Waltair and Kakinada were found to be non-significant at 5% level. Similarly the snout length of samples from Mandapam and Madras, Mandapam and Hong Kong and Madras and Kakinada were also found to be non-significant at 5% level (Table 100). The regression lines are represented as in the Pl.XVIII, Fig.4).

Eye diameter:

When the eye diameter of the samples from Mandapam, Madras, Kakinada and Hong Kong were compared, it was found to be highly significant at 5% level. Similarly the eye diameter of the samples between Mandapam and Madras were also found to be highly significant at 5% level. But the eye diameters of the specimens from Madras and Kakinada and Mandapam and Hong Kong samples were observed to be non-significant at 5% level (Table 101). However, the regression lines (Pl.XVIII, Fig.5) also indicated distinct difference between the eye diameter of the samples from Mandapam and Madras.

Pectoral fin length:

Pectoral fin length within the samples from Mandapam, Hong Kong, Waltair, Madras and Kakinada were found to be significant at 5% level. The samples from Mandapam and Madras were also analysed and found to be significant at 5% level. But when the lengths of the pectoral fins of the samples from Mandapam were compared with those of samples from Hong Kong, they were found to be non-significant. Similarly when the Madras sample was compared with that of Kakinada it was found to be non-significant at 5% level (Table 102). The regression lines (Pl.XVIII, fig.6) also illustrated the difference between Mandapam sample and other places.

Second anal spine:-

The lengths of second anal spine were tested for samples from Mandapam, Madras, Waltair, Kakinada and Hong Kong and were found to be non-significant at 5% level. Similarly the second anal spine length of the specimens from Mandapam and Hong Kong and Madras and Kakinada wefe also found to be non-significant at 5% level. But this character between Mandapam and Madras was found to be significant at 5% level of probability (Table 103). The regression line (Pl.XVIII, Fig.7) also shows marked difference between the samples from Mandapam and Hong Kong and the samples from Madras, Kakinada and Waltair.

Discussion:

From the above observations (Table 104) it could be seen that the head, pectoral fin, and second anal spine lengths were significant and eye diameter was highly significant between Mandapam and Madras at 5% level whereas these characters were non-significant at 5% level between Madras and Kakinada and Mandapam and Hong Kong. Head length, pectoral fin length and eye diameter of the samples from Mandapam, Madras, Kakinada and Waltair and Hong Kong were found to be significant and the snout length was non-significant. As the characters of samples between Mandapam and Madras were not homogeneous it could be inferred that the stock of P. macrophthalmus of Palk Bay mught be different from that of Coramandal coast (Madras and Kakinada). The samples from Madras and Kakinada have the homogeneous characters and they may belong to the same stock. Though the Mandapam and Hong Kong samples had homogenous characters, any positive conclusion could not be drawn as only a few specimens could be examined from Hong Kong.

The above inference was supported by another observation namely the largest specimen of P. macrophthalmus so far collected from Palk Bay was only 207 mm, whereas specimens measuring 280 mm were common at Madras and Kakinada. This shows that the L_{max} of Palk Bay was lesser than that of Madras, Kakinada and Waltair coasts. This difference may be due to the ecological difference of Palk Bay and coromandal coast. The maximum depth of Palk Bay varied from 5-8 fathoms whereas that of coromandal coast was between 8-30 fathoms.

TABLE 96

Regression equestions for the morphometric characters of *Pennahia macrophthalmus* of Mandapam, Madras, Kakinada, Waltair and Hong Kong.

Head length:- Total length		
	Mandapam	Y = 2.5820 + 0.2686 X
	Madras	Y = 2.2105 + 0.2766 X
	Kakinada	Y = 0.4067 + 0.1810 X
	Waltair	Y = -.6060 + 0.2907 X
	Hong Kong	Y = 8.5863 + 0.2381 X
Eye diameter - Total length		
	Mandapam	Y = 6.9470 + 0.0220 X
	Madras	Y = 1.4883 + 0.0605 X
	Kakinada	Y = 2.5627 + 0.0574 X
	Waltair	Y = 2.3974 + 0.0570 X
	Hong Kong	Y = 6.4778 + 0.0268 X
Snout length - Total length		
	Mandapam	Y = 1.8070 + 0.0773 X
	Madras	Y = 4.0769 + 0.0485 X
	Kakinada	Y = -.8140 + 0.0709 X
	Waltair	Y = 0.5127 + 0.0704 X
	Hong Kong	Y = 2.1108 + 0.0645 X
Pectoral fin length - Total lengh		
	Mandapam	Y = 1.5637 + 0.1894 X
	Madras	Y =-5.9171 + 0.2433 X
	Kakinada	Y =-1.5540 + 0.2149 X
	Waltair	Y =-1.7309 + 0.2261 X
	Hong kong	Y =12.6620 + 0.2677 X
Second anal spine length - Total length		
	Mandapam	Y = 7.3256 + 0.0240 X
	Madras	Y = 6.1680 + 0.0461 X
	Kakinada	Y = 3.9347 + 0.0617 X
	Waltair	Y = 5.3771 + 0.0504 X
	Hong Kong	Y = 8.3762 + 0.0173 X

X = Total length

TABLE 97

Sum of squares and products of Morphometric data of *Pennahia macrophthalmus* from Mandapam, Madras, Kakinada, Waltair, Hong Kong.

	No.	SX	SY	SX^2	SY^2	SXY
Head length						
Mandapam	38	5359	1518	776973	61890	219130
Madras	15	3069	882	649165	53528	186335
Kakinada	12	1520	432	200642	16220	56999
Waltair	9	1639	471	312511	25843	89854
Hong Kong	6	1199	337	240235	18971	67495
Eye diameter						
Mandapam	38	5359	381	776973	3843	54225
Madras	15	3069	208	649165	2968	43842
Kakinada	12	1520	118	200642	1192	15412
Waltair	9	1639	115	312511	1517	21743
Hong Kong	6	1199	71	240235	841	14205
Snout length						
Mandapam	38	5359	395	776973	4165	56661
Madras	15	3069	210	649165	3012	43997
Kakinada	12	1520	98	200642	848	12988
Waltair	9	1639	120	312511	1684	22841
Hong Kong	6	1199	90	240235	1360	18026
Pectoral fin length						
Mandapam	38	5359	1074	776973	31186	155493
Madras	15	3069	661	649165	30429	140410
Kakinada	12	1520	308	200642	8308	40756
Waltair	9	1639	355	312511	14733	67822
Hong Kong	6	1199	245	240235	10071	49129
Second anal spine length						
Mandapam	38	5359	407	776973	4391	57902
Madras	15	3069	234	649165	3232	48856
Kakinada	12	1520	141	200642	1693	18361
Waltair	9	1639	131	312511	1959	24564
Hong Kong	6	1199	77	240235	851	14199

TABLE 98

Corrected sum of squres and products of morphometric data, regression coefficient and deviation from average regression for Pennahia macrophthalmus from different places.

	No.	x^2	y^2	xy	b	SS	D.F.
Head length							
Mandapam	37	21213.0	1249.90	5052.06	0.2361	46.7081	36
Madras	14	21247.0	1666.40	5877.80	0.2766	40.4031	13
Kakinada	11	8108.7	668.00	2279.00	0.2810	27.4731	10
Waltair	8	14030.9	1194.00	4079.67	0.2907	7.7820	7
Hong Kong	5	634.9	42.84	151.17	0.2381	6.8464	4
Eye diameter							
Mandapam	37	21213.0	22.98	493.98	0.0232	11.4769	36
Madras	14	21247.0	72.00	1031.00	0.0485	21.9727	13
Kakinada	11	8108.7	47.67	574.67	0.0708	6.9427	10
Waltair	8	14030.9	47.55	800.23	0.5070	1.9102	7
Hong Kong	5	634.9	0.83	16.84	0.0265	0.3834	4
Snout length							
Mandapam	37	21213.0	59.08	955.61	0.0450	16.0314	36
Madras	14	21247.0	83.73	1285.20	0.0604	5.9924	13
Kakinada	11	8108.7	31.66	465.34	0.0573	4.9552	10
Waltair	8	14030.9	84.00	987.67	0.0703	14.4755	7
Hong Kong	5	634.9	10.00	41.00	0.0645	7.3524	4
Pectoral fin length							
Mandapam	37	21213.0	831.37	4030.74	0.1900	66.4782	36
Madras	14	21247.0	1300.94	5169.40	0.2432	43.2596	13
Kakinada	11	8108.7	402.67	1742.67	0.2149	28.1466	10
Waltair	8	14030.9	730.23	3172.56	0.2261	12.8750	7
Hong Kong	5	634.9	66.84	169.84	0.2675	21.4067	4
Second anal spine length							
Mandapam	37	21213.0	31.81	504.29	0.0237	19.8272	36
Madras	14	21247.0	81.60	979.60	0.0461	36.4370	13
Kakinada	11	8108.7	36.25	501.00	0.0617	5.2963	10
Waltair	8	14030.9	52.23	707.45	0.0504	16.5530	7
Hong Kong	5	634.9	10.83	10.84	0.0170	10.6489	4

TABLE 99

ANALYSIS OF COVARIANCE

Source of variation	D.F.	Sum of squares	Mean squares	Observed F	5%
Head length					
Deviation from individual regression between places. (Mandapam, Hong Kong Waltair, Madras and Kakinada)	70	129.2127	1.845	4.01*	2.50
Difference between regression	4	29.6650	7.4160	-	-
Deviation from average individual regression	74	158.8780	-	-	-
Deviation from individual regression between places. (Mandapam and Hong Kong)	40	53.5545	1.3388	243.40@	251
Difference between regression	1	0.0055	0.0055	-	-
Deviation from average individual regression	41	53.5600	-	-	-
Deviation from individual regression between places. (Mandapam and Madras)	49	87.1120	1.7770	8.84*	4.02-4.03
Difference between regression	1	15.7150	15.7150	-	-
Deviation from average individual regression	50	102.8262	-	-	-
Deviation from individual regression between places. (Madras and Kakinada)	23	67.8762	2.9511	25.66@	248-249
Difference between regression	1	0.1147	0.1147	-	-
Deviation from average individual regression	24	67.9909	-	-	-

* Significant of at 5% level; @ Non-significant at 5% level; D.F. Degree's of freedom.

TABLE 100

ANALYSIS OF COVARIANCE

Source of variation	D.F.	Sum of squares	Mean squares	Observed F	5%
Snout length					
Deviation from individual regression between places.(Mandapam, Hong Kong, Waltair, Madras and Kakinada)	70	66.7744	0.9539	2.20@	2.50
Difference between regressions	4	8.4171	2.1042	-	-
Deviation from average individual regression	74	75.1917	-	-	-
Deviation from individual regression between places. (Mandapam and Hong Kong)	40	23.3811	0.5841	2.43@	251
Difference between regressions	1	0.2401	0.2401	-	-
Deviation from average individual regressions	41	23.6502	-	-	-
Deviation from individual regression between places. (Mandapam and Madras)	49	38.0041	0.7751	6.04@	252
Difference between regressions	1	0.1282	0.1282	-	-
Deviation from average individual regression	50	38.1323	-	-	-
Deviation from individual regression between places (Madras and Kakinada)	23	28.9154	1.2571	2.33@	4.28
Difference between regressions	1	2.9310	2.9310	-	-
Deviation from average individual regresssion	24	31.8464	-	-	-

@ Non-significant.

TABLE 101

ANALYSIS OF COVARIANCE

Source of variation	D.F.	Sum of squares	Mean squares	Observed F	5%
Eye diameter					
Deviation from individual regression between places. (Mandapam, Hong Kong, Waltair, Madras, and Kakinada)	70	24.7181	0.3531	12.99**	2.50
Difference between regressions	4	18.3493	4.5873	-	-
Deviation from average individual regression	74	43.0674	-	-	-
Deviation from individual regression between places. (Mandapam and Hong Kong)	40	11.8603	0.2965	44.25@	251
Difference between regressions	1	0.0067	0.0067	-	-
Deviation from average individual regression	41	11.8667	-	-	-
Deviation from individual regression between places. (Mandapam and Madras)	49	17.4693	0.3565	41.20**	4.02-4.03
Difference between regressions	1	14.6889	14.6889	-	-
Deviation from average individual regression	50	32.1582	-	-	-
Deviation from individual regression between places. (Madras and Kakinada)	23	10.9476	0.4759	8.45@	248-249
Difference between regressions	1	0.0563	0.0563	-	-
Deviation from average individual regression	24	11.0039	-	-	-

** Highly significant; @ Non-significant.

TABLE 102

ANALYSIS OF COVARIANCE

Source of variation	D.F.	Sum of squares	Mean squares	Observed F	5%
Pectoral fin length					
Deviation from individual regression between places. (Mandapam, Hong Kong, Waltair, Madras and Kakinada)	70	171.1661	2.4450	3.54*	2.50
Difference between regressions	4	34.7039	8.6750	-	-
Deviation from average individual regression	74	25.8700	-	-	-
Deviation from individual regression between places. (Mandapam and Hong Kong)	40	87.8849	2.1971	3.24@	4.08
Difference between regressions	1	7.1226	7.1226	-	-
Deviation from average individual regression	41	80.7623	-	-	-
Deviation from individual regression between places (Mandapam and Madras)	49	108.7376	2.2190	13.58*	4.03-4.04
Difference between regressions	1	30.1342	30.1342	-	-
Deviation from average individual regression	50	138.8720	-	-	-
Deviation from individual regression between places. (Madras and Kakinada)	23	71.4062	3.1046	1.52@	4.28
Difference between regressions	1	4.7268	4.7268	-	-
Deviation from average individual regression	24	76.1330	-	-	-

* Significant; @ Non-significant.

TABLE 103

ANALYSIS OF COVARIANCE

Source of variation	D.F.	Sum of squares	Mean squares	Observed F	5%
Second anal spine length					
Deviation from individual regression between places. (Mandapam, Hong Kong, Waltair, Madras and Kakinada)	70	88.7620	1.2681	2.35@	2.50
Difference between regression	4	11.9481	2.9871	-	-
Deviation from average individual regression	74	100.7102	-	--	-
Deviation from individual regression between places. (Mandapam and Hong Kong)	40	30.4761	0.7611	26.24@	251
Difference between regression	1	0.0294	0.0294	-	-
Deviation from average individual regression	41	30.5055	-	-	-
Deviation from individual regression between places. (Mandapam and Madras)	49	56.2640	1.1481	4.61*	4.03-4.04
Difference between regressions	1	5.2939	5.2939	-	-
Deviation from average individual regression	50	61.5579	-	-	-
Deviation from individual regression between places. (Madras and Kakinada)	23	41.7340	1.8145	1.26	248-249
Difference between regressions	1	1.4412	1.4412	-	-
Deviation from average individual regression	24	43.1752	-	-	-

* Significant; @Non-significant

TABLE 104

Summary of the analysis of covariance of the morphometric characters of *P. macrophthalmus* of different places.

Source of variation	Head length	Pectoral fin length	Snout length	Eye diameter	Anal spine length
Mandapam, Madras, Kakinada Waltair and Hong Kong.	*	*	@	**	@
Mandapam and Hong Kong	@	@	@	@	@
Mandapam and Madras	*	*	@	**	*
Madras and Kakinada	@	@	@	@	@

* Significant at 5% level

** Highly significant at 5% level

@ Non-significant at 5% level

VIII. PARASITES

Apart from the health and economic point of view the study of the parasites of a fish is important as it may throw light on the identification of races (Margolis *et al*, 1968). Host specificity of many of the parasites are reported. Many crustacean parasites and a few nematode parasites are recorded from the sciaenid fishes.

Gnanamuthu (1947, 1947a, 1951) reported the copepod parasites *Caligus sciaenae* and *Lernanthropus sciaena* from *Sciaena glaucus* and he also described *Peniculus sciaenae* from *Sciaena albida*. Rangnekar (1956, 1959) described *Brachiella albida* from the sciaenid fish *Otolithus ruber* and *Sciaenophilus pharaonis* from *Sciaena semiluctousa*. Pillai (1961, 1962a and 1962b) recorded the copepod parasites *Brachiella otolithi*, *Caligus annularis* and *Sciaenophilus tenuis* from *Otolithus argenteus*, *Otolithus* sp. and *Johnius* sp. respectively; Kirtisinghe (1964) reported *Brachiella merlucci* and *Sciaenophilus benedeni* from *Sciaena diacanthus*. Apart from the copepod parasites an external and a gonadial nematodes parasites have also been observed in *P. macrophthalmus*.

Nematode parasites of P. macrophthalmus:-

Mohan (1970) reported the occurrence of *Philometra rajani* in the ovary of *P. macrophthalmus* and investigated its seasonal occurrence and intensity of infestation. When the fishes are heavily infeated the parasite are seen hanging through the anal opening. The heavily infected ovaries appear black and the number of ova in the ovary were also ~~a~~ reduced drastically. Besides the gonadial parasites another external nematode parasites was also observed embedded in the base of caudal, dorsal and anal fins.

Class: Nematoda
Order: Filarioidae
Family: Philometridae
Genus: <u>Philometra</u> Costa

Body elongate, rounded at both extremities. Lateral fields broad; mouth funnel shaped; oesophagus short, more or less swollen anteriorly and cylindrical posteriorly and accompained by a long dorsal unicellular gland; anus non-functional in adult female; Tail truncate in male with a pair of large lateral processes posteriorly; cloacal aperature terminal; testis single; tail short and bluntly rounded in female. Ovaries reflexed.

<u>Philometra filamentosa</u> sp.nov.
(Plate XIX Fig. 1 a & b)

<u>Philometra rajani</u> Mohan (nec. Mukerjee) 1970, <u>J. Mar. Biol. Ass. India</u>, <u>12</u>:226-227.

Material:

Holotype: CMFRI No.113/1

Host: P. macrophthalmus; Locality: Mandapam
Female; 8-4-1972; Site: ovary.

Paratypes: CMFRI No.113/2-3

Host: P. macrophthalmus; Locality: Mandapam
Female; 10-5-72; Site: ovary.

Hosts: Pennahia macrophthalmus, Johnieops sina
J. coitor, Otolithus ruber.
Locality: Mandapam and Rameswaram.

Cuticle smooth, semitransparent, anterior and posterior extremities rounded, mouth funnel-shaped without lips or papillae, oesophagus long and cylindrical, intestine extends almost entire length of body as a black tube without anal opening, uterus extends almost the whole length laden with eggs; anterior ovary bent inwards and sickle-shaped; posterior ovary enlarged; viviparous; eggs rounded, larvae filiform measure about 0.4 mm; adult worm measures about 60 to 80 mm. It occurs in ovaries of sciaenids. It is rarely found in testes of the above mentioned species. The percentage of infection range from 2 to 10 percent in various months.

Philometra nairii sp.nov.

(Plate XIX, Fig.2 a,b,c,d)

Host: *Pennahia macrophthalmus*; Type locality: Palk Bay (Mandapam)

Material:

Holotype: CMFRI No.193/1. Host: P. macrophthalmus;
Locality: Mandapam (Palk Bay); Female,
9-2-1969; site of infection: Caudal fin.

<u>Paratype</u>: CMFRI No.194/1. <u>Host</u>: <u>P. macrophthalmus</u>; <u>Locality</u>: Mandapam (Palk Bay); Female, 15-4-1970; <u>site of infection</u>: Caudal fin.

<u>Syntypes</u>: CMFRI No.195/1-5. <u>Host</u>: <u>P. macrophthalmus</u>; <u>Locality</u>: Mandapam; Female, 15-4-1970, 28-7-1972; <u>site of infection</u>: Caudal fin and dorsal fin.

<u>Description</u>:

Body short, female measures 10-15 mm length, 1.1 mm thick, mouth funnel shaped, oesophagus short measures about 0.5 mm; caudal end of female pointed, curved inside; ovary occupies the whole body, anteriorly rounded and posteriorly pointed; intestine not reaching posterior end and terminating bluntly without opening to exterior in adult; hooks or papillaei absent; posterior end of cuticle with constrictions; embryo filiform measuring about 0.1 mm in length and 0.02 mm in width; intestine of embryo extending to cuticle; tail curved inside.

The parasite is enclosed inside a sheath which is embedded at the site of infection. It occurs in <u>Nibea soldado</u> and <u>Johnieops sina</u> also.

<u>Remarks</u>:

The parasite does not seem to harm the fishes. More than 3 or 4 parasites were not observed in one fish, and the usual site of infection was caudal fin though the parasites were often seen in the dorsal, anal and pectoral fins also. There seems to be no size or sex preference for the infection of the parasite.

Etiology:

The parasites is named after Dr. R.V. Nair, former Director of Central Marine Fisheries Research Institute.

FISHERY AND DISTRIBUTION OF THE SCIAENID FISHES OF INDIA

Introduction:

Sciaenid fishes formed about 3.3 per cent of the total annual marine fish landings of India for the period 1960 - 1972 (CMFRI, 1972) and about 5.2 percent of marine landings in Tamilnadu for the same period (Table 105); Maharashtra ranked first in sciaenid fish landings where it formed 6.1% of the total marine fish landings of he State followed by Tamilnadu (Rao, 1969). Annual landings of sciaenid fishes in India for the year 1972 were 39099 tonnes (Table 106) and those of Tamilnadu 6230 tonnes. With more emphasis on the trawling by mechanised boats, the landings of the sciaenid fishes and its importance is bound to go up.

Species composition of economically important sciaenids:

Though 37 species of sciaenids occur in from the Indian coasts, only about 13 species form a fishery at different places (Plate XX, Fig.1). Sciaenid fishes contributed about 25% of the trawl catches in Bombay and Sourashtra region (Rao, 1969). During the year 1972, Ghol (*Nibea diacanthus*) formed about 6%, koth (*Otolithoides biaurites*) about 1.5% and other smaller sciaenids like *Johnius glaucus*, *Johnius elongatus* and *Johnieops macrorhynus*, formed about 18% of the total trawl landings of Bombay.

The fishery of the species of sciaenid fishes differed from place to place. In Gujarat coast *Otolithes cuvieri* formed about 45% whereas *Nibea diacanthus* and *Johnius glaucus* formed 15% each and *Otolithoides biaurites* and *Johnieops sina* about 10% of the total sciaenid catches.

Along the Bombay coast during 1972 *Johnius glaucus* formed 30% while *Nibea diacanthus* and *Otolithes cuvieri* constituted 20% each and *Otolithoides biarutes* 10% of the total sciaenid catches. In Mysore coast *Johnieops osseus* formed 50%, *Otolithes cuvieri* and other species 20% each and *Johneiops sina* 10%. In Kerala coast *Otolithes cuvieri* and *Johnieops osseus* constituted 30% each and *Johnieops sina* 20% of the tota sciaenid landings. Along the Tamilnadu coast *Pennahia macrophthalmus* formed 40%, *Johnius carutta*, *Otolithes ruber* 10% each and other sciaenids 20%. In Andhra coast *Pennahia macrophthalmus* formed 40%, *Johnius carutta*, *Otolithes ruber* and *Johnieops sina* 10% each of the sciaenid fish catches of the state; in Orissa coast *Johnius carutta* and *Chrysochir aureus* formed 20% each, and *Otolithes ruber* and *Pennahia macrophthalmus* 15% each of the sciaenid fish catches. In Bengal coast and in the estuaries of the river Ganges, *Otolithoides pama* formed 40%, *Johnius coitor* 15%, *Nibea albida*, *Macrospinosa cuja* and *Johnieops dussumieri* 10% each and *Otolithoides biarrites* 5% of the total sciaenid landings.

From the above observations it was evident that the fishery of the different species varies from one State to another. Along the West coast *Johnius glaucus*, *Johnieops* ~~osse~~ *osseus*, *Nibea diacanthus* and *Otolithes cuvieri* form the main fishery whereas in the East coast *Pennahia macrophthalmus* *Chrysochir aureus*, *Otolithes ruber* and *Otolithoides pama* and *Johnieops sina* form the fishery.

Distribution of spe/cies:-

Of the thirty seven species of sciaenids ~~are~~ so far reported from Indian coasts, some have restricted distribution whereas others occur throughout the entire coast.

Pterotolithes maculatus, *Otolithoides pama*, *Panna microdon*, *Johnius coitor*, *A. nibe* and *C. aureus* are found only along the East coast of India whereas *Otolithes versicolar* *Nibea semilutousa*, *Nibea chui* and *Johnius glaucus* occur only along the West coast. Among these species *Otolithoides pama* and *Johnius coitor* and *Macrospinous cuja* are distributed in the estuaries of Ganges and in the coastal belt of Sunderbands. The pattern of distribution of species of sciaenid along the coast of India is shown in (Plate XX, Fig.2-6). It may be observed that the *O. biauritus* formed a fishery only along the North West coast and North east coasts of India. Its occurrence is rare in Palk Bay and it does not form a fishery in other places. On the other hand *Nibea diacanthus* which forms one of the important fisheries along the north west coast of India occurr in shoals during the period November to March in Gulf of Mannar.

Species composition at Mandapam:

Pennahia macrophthalmus formed about 60% of the total ~~SE~~ sciaenid catches of the trawlnets operated in Palk Bay followed by *Johnieops sina*, *O. ruber* 10% each and other sciaenid catches. In the Gulf of Mannar coast of Mandapam 50% of the sciaenid fishery was formed by *J. osseus*, *J. sina* (30 and 20% each), *J. carutta* and *J. dussumieri* (15% each). It is of interest to note that *P. macrophthalmus* which forms a fishery in Palk Bay side seldom occurs in Gulf of Mannar. The Palk Bay catches represent those of East coast of India and the Gulf of Mannar catches resemble those of West coast of India in species composition.

Fishing seasons:-

Generally smaller sciaenids formed a fishery throughout the year but for the monsoon months when fishing activities are suspended. However, landings were recorded more during winter months viz. November, December, January and February. According to Bhimachar and Venkataraman (1952) the fishing season for the smaller sciaenids like *J. sina* and *J. belangeri* was from January to July and that of *O. cuvieri* was from April to August in Malabar coast.

The fishery of the larger sciaenids like *N. diacanthus* and *O. biaurites* showed seasonal variation. The fishing season for *N. diacanthus* along the West coast of India was during February to April (Jayaraman and Gogate, 1957; Jayaraman, *et al* 1959). *N. diacanthus* occurs in shoals in Gulf of Mannar during November to March. According to Bhatt *et al* (1967), *O. biaurites* formed a fishery along the North-West and North East coast during November to February.

In Palk Bay and Gulf of Mannar coasts of Mandapam the fishing seasons change according to weather conditions. During the months of November to February the Palk Bay became rough and choppy and it was difficult to operate the nets due to the onset of North-East monsoon. During this period Gulf of Mannar was calm and the fishing activity was concentrated there. From March to October Gulf of Mannar became rough and hence the fishing activity is shifted to Palk Bay.

Fishing crafts and gears:-

In Mandapam area the common gears employed are trawl nets, gill nets, 'Madi valai', shore seines, 'Olai valai', traps, hooks and lines and cast nets. About 80% of the sciaenid fishes are landed by trawl nets operated by machanised boats. Details of the engines and boats operating in this areas are given in Table 107. The marine engines commonly used are 'Marna' with four cylinders which formed about 40% of the engines used here followed by 'Ruston' 35%. Other engines were 'Medows', 10%, 'Buch', 7% and 'Yarnmar', 3%, A few boats are also fitted with engines like 'Leyland', 'Torpedo' and &Kirlosker' also.

Most of the 'Marna' (Norway) and 'Yarnmar' (Japan) engines were imported before 1970 and now due to present import restrictions only Indian made engines like 'Medows', 'Ruston', 'Kirlosker' fitted to 28' and 30' boats are used.

Trawl net:-

The trawl net is essentially a bag net which is dragged over the bottom or in the mid water. Most of the trawlnets are made of nylon monofilament (Garfil twine) of 3/4 mm size. The upper edge of the mouth was supported by the head rope which is kept in position by the floats. The lower side of the mouth is supported by the foot rope which carries the weights. The length of the head rope depended on the formulae H = 43.6 P + 660 where 'H' is the length of head rope and 'P' the horse power of the engine. The net proper consists of cod-end, throat, belly and wings. The cod-end is the narrow section of the tapering bag measuring 2.0-2.5 meters. Its posterior end is tied with a rope by means of a special knot which could be released easily for emptying the catch. The cod-end is followed by the 'throat'. The later is preceded by the belly which measures about 15-17 meters. The wings are the part of the net extending forward from each side of the belly ~~about~~ and help in preventing the fishes from escaping It measures about 10-15 meters. The breadth of the wings ranges from 1.5 to 2 m. A nylon warp of about 10-15 m length and about 1 cm in thickness is used for dragging the net. The outer end of the trawl net wings are kept open by the 'Dan-leno'.

The otter board is a rectangular wooden structure with iron reinforcement which enable the mouth of the net to be kept open at a desired depth. Each otter board weighs about

45 kg measuring 1.5 x 0.70 x 0.03 meters. One otter board is attached to each side of the warp, in such a way that it is an angle with the direction of the tow.

The cod-end, belly and the wings of the trawl nets of Mandapam area have the mesh sizes 2 cm, 4 cm and 5 cm respectively.

Gill net:-

The gill net is a long wall like net consisting of a number of pieces tied together. It has a head rope with floats and foot rope with sinkers which make the net remain in vertical position in water. The mesh size ranges from 4 to 10 cm according to the size of the fish to be caught. The length of the net also ranges from 100-300 meters. The net consists of many pieces which are connected together depending on their availability. The vertical height of the net is 2-3 meter. It is operated with the help of Tuticorin type of sail boats or catamarans. The nets are fabricated with hemp twine or nylon Garfile twine (monofilament). Sciaenid fishes like Otolithes ruber, Nibea diacanthus and N. maculatus are caught by these gill nets along with other fishes.

Shore seine:

It is operated with the help of a Tuticorin type of boat which is used for carrying the net and to encircle the shoals of fishes. The shore seine or the 'Karai Valai' as it is known in Tamil has a bag, belly and wings. The mesh size of the bag is about 1.5 cm and the bag proper measures about 10-12 m in length. The belly measures about 40 m. Its mesh size is 2.5-3.0 cm. The cotton wings on each side is followed by hemp wings, in which the mesh size is about 20 cm. The size of the meshes increases progressively. The hemp wing on either side is about 400 m and is bounded by a head and a foot rope to which floats and sinkers are attached. The distance between each float is 2.5 m and sinkers about 8 m. At the month of the bag, the head rope had a master float and two smaller floats on each side.

For operating, the net is loaded ina Tuticorin type of boats. One end of the warp is held on the shore by a person and the boat is manned by a crew of 8-10 men. When a shoal of fish is sighted the net is payed around the shoal and the other end of the warp is brought to the shore. The net is dragged by 12-20 men on each side. As the net comes close to the shore, the two parties dragging each end of the warp also move closer. When the bag portion is sighted the wings are guarded so as to remain as a wall to prevent the escape of the fishes.

Though the shore seines are one of the important fishing gears of this area before the introduction of the mechanised boats in 1965, now the number of shore seines operated in this area had considerably reduced due to changing over to mechanised trawling.

Bag net:

Bag nets are operated with catamaram. A catamaram was made up of three large logs of wood tied together. The middle log is at a lower level then the other two. Usually two catamarams are used for dragging the net. One of the catamaram is larger being about 7 meters in length and about one meter in width. The smaller one is 5 long and 0.8 m wide. Sometimes a sail is also used. The two crafts are tied together at their anterior ends to reduce friction. When the sail is used, it is common for both the crafts. Each craft is operated by a crew of two.

The bag net is known as 'Madivalai' in Tamil. It consists of a bag like portion with side wings, and is about 10 m long and 2 m wide at mouth. The cod end is about 60 cm long with a mesh size of about 5 mm. The bag is preceded by the hemp wings which measure about 50 m on each side. It is attached to the warp of the same length. A single float is attached to the head rope and a sinker to the foot rope.

During 1961-62 about 100 units of the 'Madivalai' were operating in Thangachimadam, in Palk Bay whereas only 2 or 3 units are operating now. The decrease is mainly due to the introduction of trawl nets operated by the mechanised boats.

Catch statistics of sciaenid fishes:-

Statewise catch analysis showed that the landings of sciaenids in the maritime states Gujarat, Maharashtra, Karnataka

Kerala, Tamilnadu, Andhra, Orissa and West Bengal were 3770, 12936, 1372, 3683, 5898, 5794, and 3095 tonnes respectively in the year 1971 (CMFRI 1971). The State-wise landings of the sciaenid fishes for the years 1960-1972 and the total landings of sciaenids for the same period are tabulated (Table 108). It was observed that the landings of sciaenids increased in the states like Maharashtra, Tamilnadu, Orissa and West Bengal during this period. In Maharashtra the landings of sciaenids increased from 5838 tonnes in 1960 to 11097 tonnes in 1972 (Plate XXI, Fig.1) and in Tamilnadu from 5809 in 1960 to 6776 in 1972 (Plate XXI, Fig.2). Percentage of sciaenids of each State in total annual landings of sciaenids in India is calculated and found that the sciaenid fish landings from Maharashtra and Tamilnadu coasts accounted for 31.6% and 23.6% respectively of the total annual landings of the sciaenid fishes (Plate XXII, Fig.1). When the average were taken for the year 1960-1971, Maharashtra ranks first in the landings of sciaenids with 9238 tonnes and 31.6% of the total sciaenid fish landings, followed by Tamilnadu (7000 tonnes and 23.6%). Andhra (3937 tonnes and 14.0%), Kerala (3527 tonnes and 12.5%), Gujarat (2408 and 8.1%), Karnataka (1799 tonnes and 6.6% and Orissa and West Bengal (1128 tonnes and 3.5%) (Table 109).

Considerable increase in the sciaenid fish landings was noticed in the States like Maharashtra, Tamilnadu and Orissa and West Bengal since 1969. Landings in West coast of India accounted for about 60 percent of the total sciaenid catches. Out of the 60 percent, about 45% of the sciaenids were landed from the North West coast. It was seen from the data that Gujarat and Maharashtra coasts were highly productive in sciaenid fish resources.

An examination of the sciaenid fish landings along the east coast and west coast in relation to the total marine fish landings showed (Table 110) that the percentage of the quantity of sciaenid fishes landed along the East coast (Plate XXII, Fig. 2) was more (6.6%) than the West coast where (Plate XXII, Fig.3) it was only 2.6%. But the total sciaenids landed (average for 12 years period) was 16876 tonnes along the West coast and 12470 tonnes in the East coast. Due to the large quantities of the pelagic fishes like sardines and mackerels landed along the West coast the percentage of sciaenids were observed to be low along the West coast. However it was observed that the sciaenid fishes form a more important component of the fishes landed in the East coast rather than in the West coast.

Disposal of the catches:

When caught in large quantities sciaenids are salted and dried. The smaller sciaenids are salted along with silver bellies in Mandapam area. Salt dried sciaenid fishes are sold at the rate of 50 paise per kg. in Mandapam area. The smaller sciaenids are also utilised for making fish meal by the fish meal plant at Mandapam.

By-product of sciaenid fishes:

The swim bladder of the larger sciaenids like *Nibea diacanthus* and *Otolithoides biaurites* are sold separately. Gas bladder from a *Nibea diacanthus* of one meter length is about Rs.2/- in Mandapam and Keelakarai area. The fresh gas bladders are collected dried and exported to Far Eastern countries for the preparation of 'Isinglass' which is used as a clarifying agent in the manufacture of wine. Veraval, Satpati and Versova are some of the places of north-west coast of India from where gas bladders of fishes like *Muraenesox* sp., sciaenids and catfishes are being collected and exported in large quantities (Table 109). 80 per cent of the gas bladders are exported to Singapore and about 15% and 5% were to Hong Kong and Malayasia respectively. In the World market the price of shark fins and gas bladder has nearly trebled since 1963. The price was Rs.8.90/kg in 1963 whereas in 1975 it was about 25 Rs./kg.

Conclusion:

Sciaenid fishes form one of the important food fishes of India. It constituted about 4% of the total marine fish landings in India. The distribution of the different species of sciaenids showed distinct differences between East and West coasts. Maharashtra coast is rich in sciaenid fish resources and it ranks first in the sciaenid fish landings with about 30% of the total sciaenids landed. Based on the data for 1960 - 1975 west coast of India is clearly seen to be richer in sciaenid fish resources than the East coast. Trawlers are chiefly engaged in exploiting the demersal fish resources of which the sciaenids form one of the chief constituents. With more emphasis being laid on mechanised fishing, the importance of sciaenid fishes is bound to go up with new fishing grounds coming under more intensive exploitation.

TABLE 105

Details of mechanised boats operating in Mandapam area (1968-1970)

Name of Engines	Manufacturing country	Horse power (ranges)	R.P.M.	Oil consumption (litre per km)	No.of cylinders	Length of boats
Marna	Norway	24;36;48;60	1600	3½;4½;6½;7½	2;3;4(4 super charge)	28;30;32;40
Yarmmar	Japan	24;45;87	900	3;4½;7½	2;3;5	20;32;43
Ruston	India	24;36;48	1500	3;4;5½	2;3;4	20;28;32
Kirlosker	India	38.5;56	1500	4;5½	4;6	30;32
Kelvin	India	33;44.5	1000	4;5½	3;4	30;32
Medows	India	48;54	1500	6;7	4;4	32;32
Listen	England	40;87	1500	5;9	3;6	30;43
Torpedo	Czechoslavakai	36;48	1500	4;5½	3;4	30;32
Daiya	Japan	25;36;50	1000	3;4½;5½	2;4;4	28;30;32
Buck	Japan	25;50	1500	3;5½	2;4	28;32
Leyland	India	58;90	2400	5;10	6	32;43

TABLE 106

State wise landings of sciaenid fishes in tonnes with its percentages in total marine fish landings

(1960 - 1972)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Gujarat	2291 (1.7)*	1356 (1.4)	4410 (4.5)	2469 (2.4)	2448 (2.6)	1613 (2.0)	1543 (1.8)	1411 (1.9)	1469 (1.7)	2211 (2.6)	2889 (4.3)	3770 (4.4)	3806 (5.0)
Maharashtra	5838 (4.4)	11203 (9.9)	9636 (7.5)	7939 (6.3)	8875 (6.7)	8038 (6.0)	7856 (5.8)	7581 (5.6)	7141 (5.7)	10821 (5.5)	13003 (6.1)	12936 (5.4)	11097 (5.0)
Karnataka	1610 (1.6)	2706 (15.2)	6297 (13.9)	1196 (3.0)	1237 (1.2)	1288 (1.8)	1508 (0.5)	492 (1.0)	821 (0.9)	1187 (1.5)	1885 (1.6)	1372 (1.3)	2099 (2.5)
Kerala	4478 (1.2)	2501 (0.9)	1228 (0.6)	1674 (0.8)	3647 (1.1)	3267 (0.9)	4921 (1.4)	4310 (1.1)	3630 (1.0)	3195 (1.0)	5792 (1.4)	3683 (0.8)	5835 (2.8)
Tamilnadu	5809 (5.3)	7746 (6.2)	6150 (5.5)	5002 (4.5)	5854 (4.4)	4596 (4.3)	6489 (4.3)	7874 (5.9)	8577 (6.4)	9481 (6.2)	10526 (6.7)	5898 (3.0)	6230 (4.0)
Andhra	4392 (7.7)	4035 (7.3)	3963 (6.5)	3427 (5.2)	2422 (3.3)	3704 (4.8)	3144 (3.9)	3232 (4.2)	2557 (8.2)	6874 (8.8)	4091 (5.4)	5794 (6.9)	7169 (8.5)
Orrisa and West Bengal	529 (9.2)	370 (4.0)	757 (9.0)	863 (7.6)	713 (6.6)	902 (7.3)	440 (4.9)	412 (2.1)	1600 (5.3)	1274 (5.5)	2617 (5.3)	3065 (11.2)	2211 (15.5)

* % of sciaenids in total marine fish landings given in the parenthesis.

TABLE 107

State wise landings of sciaenids in tonnes for 1960 - 1972 with its the percentages to annual landings of sciaendis

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Average (%)	Rank
Annual landings of sciaenids (All India)	24947	29917	32439	22570	25197	23468	25901	25312	25822	35043	41803	36518	39099		
Gujarat	2291 (9.1)	1356 (4.5)	4410 (13.5)	2469 (10.9)	2449 (9.7)	1613 (6.8)	1543 (5.9)	1411 (5.5)	1496 (5.7)	2211 (6.3)	3889 (9.2)	3770 (10.3)	3806 (9.7)	8.2	5
Maharashtra*	5838 (23.4)	11203 (37.4)	9636 (29.7)	7939 (35.1)	8875 (35.2)	8038 (34.3)	7856 (30.4)	7581 (29.9)	7141 (27.3)	10821 (30.8)	13003 (30.5)	12936 (35.4)	11203 (28.6)	31.4	1
Karnataka	1610 (6.4)	2707 (9.0)	6295 (19.4)	1196 (5.2)	1237 (4.9)	1288 (5.6)	1508 (5.8)	492 (1.1)	821 (3.2)	1187 (3.4)	1885 (4.8)	1372 (3.7)	2099 (5.3)	6.0	6
Kerala	4478 (17.9)	2501 (8.4)	1228 (3.8)	1674 (7.4)	3647 (14.4)	3267 (13.9)	4921 (18.9)	4310 (17.9)	3630 (14.0)	3195 (9.1)	5792 (13.9)	3683 (10.0)	5835 (14.9)	12.5	4
Tamilnadu **	5809 (23.3)	7746 (25.8)	6150 (18.9)	5002 (22.2)	5854 (23.2)	4596 (19.6)	6489 (25.1)	7874 (31.2)	8577 (33.3)	9481 (27.0)	10526 (25.2)	5898 (16.1)	6776 (17.3)	23.6	2
Andhra	4392 (17.7)	4035 (13.5)	3963 (12.3)	3427 (15.2)	2422 (9.6)	3704 (15.9)	3144 (12.2)	3232 (12.8)	2557 (12.0)	6874 (19.7)	4091 (9.8)	5794 (15.8)	7169 (18.1)	14.0	3
Orrisa and Bengal	529 (2.1)	370 (1.3)	757 (2.4)	863 (3.9)	713 (2.8)	902 (3.9)	440 (1.7)	412 (1.6)	1600 (6.2)	1274 (3.7)	2617 (6.3)	3065 (8.3)	2211 (5.6)	3.5	7

* including Goa ** including Pondichery.

TABLE 108

Sciaenid fish landing along West and East coasts for the year 1960-1972

West Coast	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
West coast													
Annual Marine fish landings	707105	494404	463381	469045	645675	620146	627052	622249	643624	649107	811940	871864	620380
Sciaenids	14217	17766	21569	13278	16207	14206	14644	13794	13088	17414	24569	21761	22943
Percentage	2.0	3.5	4.6	2.9	2.5	2.2	2.3	2.2	2.0	2.6	3.0	2.4	3.7
East coast													
Annual Marine fish landings	170499	187710	180530	185691	213678	183408	237669	227512	240436	262918	272002	281181	262317
Sciaenids	10730	12151	10870	9292	9898	9202	10135	11518	16543	17629	17234	14757	16156
Percentage	6.2	6.4	6.0	5.0	4.2	5.0	4.2	5.0	6.8	6.7	6.3	6.2	6.1

Average for West coast - 2.6%
Average for east coast - 5.6%

TABLE 109

Export figures of shark fins and fish maws (1963 - 1972)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972*
Quantity (in tonnes)	342	378	244	139	296	331	214	291	295	293
Value (in 1000 rupees)	3051	2882	2032	1340	3709	4689	4550	5997	5189	6926

* Seafood export J., v(2). Feb. 1973; Others, Seafood export J.iv(2). Feb.1972.

TABLE 110

Catch statistics of sciaenid fishes from 1950 - 1972

Years	Annual landings of sciaenids (tonnes)	Annual marine fish landings (tonnes)	Percentage of sciaenids
1950	29822	580021	5.1
1951	33214	533916	6.2
1952	37378	528348	7.0
1953	56298	581463	9.6
1954	29556	588258	5.0
1955	32671	598725	5.4
1956	24481	718779	3.4
1957	38427	875176	4.3
1958	25565	755994	3.3
1959	20447	574587	3.4
1960	24947	879681	2.8
1961	29917	683569	4.3
1962	32439	644244	5.0
1963	22570	655484	3.4
1964	25197	859582	2.9
1965	23468	832777	2.8
1966	25901	890311	2.9
1967	25312	860879	2.9
1968	25822	902772	2.8
1969	35043	913630	3.8
1970	41803	1085607	3.8
1971	36518	1154822	3.1
1972	39099	974459	4.0

TABLE 111

Catch statistics of sciaenid fishes and marine fishes in Tamilnadu from 1960 - 1972

	Sciaenid fish (in tonnes)	Marine fish landing in Tamilnadu	Percentages of sciaenids in total
1960	5809	107913	5.3
1961	7746	123593	6.2
1962	6150	111622	5.5
1963	5002	109602	4.5
1964	5854	131309	4.4
1965	4596	106029	4.3
1966	6489	147541	4.3
1967	7874	132505	5.9
1968	8577	133075	6.4
1969	9481	151876	6.2
1970	10526	155516	6.7
1971	5898	160214	3.6
1972	6230	155264	4.0

SUMMARY

The family Sciaenidae is revised based on external and internal characters such as gas bladder, otolith (sagitta), disposition of sensory pores on snout, dentition etc. The family is sub-divided into five sub families and sixteen genera comprising thirty seven species. Synoptic keys to the sub families, genera and species of sciaenids occurring in India have been devised. Each species is described with its synonyms and salient diagnostic morphometric and meristic characters. Arithmetic mean, standard deviation, standard error and the percentage of coefficient of variation of each character are tabulated.

Food and feeding habits of *Pennahia macrophthalmus* have been studied by the method of index of preponderance. *Pennahia macrophthalmus* is a carnivore feeding chiefly on fishes, prawns and *Acetes* sp. The feeding intensity is more during June, July and September. Though the species feeds on fishes almost throughout the year, penaeid prawns form one of the main constituents of food during January to March. Variations in food of different size groups show that though fishes and prawns are consumed by all length groups, bottom animals like isopods, echiuroids and annelids also formed the food of fish above 120 mm in length. Food of the sciaenid fishes *Johnieops sina*, *Johnius belengeri* and *J. carouna* was also studied. These fishes were also found to be carnivores.

Length-weight relationship of *P. macrophthalmus* was calculated by using the formula log W = log a + n log b. The difference in the length-weight relationship of males and females was found to be significant at 5% level while that of different size groups was non-significant at 5% level.

The relative condition factor for the immature and mature fish was found to vary but the causative factor for such fluctuation may be reasons other than food or maturity.

Maturity stages were determined by ova diameter studies and by macroscopic examination of the gonads following the stages suggested by International Council of Exploration of Seas. Seven stages were distinguished in *P. macrophthalmus*. Immature ova measured about 0.3 mm whereas maturing ova were 0.4 to 0.4 mm and the matured or ripe ova measured 0.6 to 0.8 mm. The fishes spawned once in a year with a peak during March-April. But the spawning season extended from February to August. Spawners with oozing ova and spent fish with residual ova were collected from Rameswaram during March. Gonadosomatic index was calculated and it was found to vary from 1.4 to 4.6. The mean gonadosomatic index was 3.03. The index was more than the mean gonadosomatic index from February to August indicating the prolonged breeding season of the fish. Length at first maturity of the fish was determined by graphical method and by studying the ova diameter. The length at which fifty percent of the fishes were mature was considered to be length at first maturity. *P. macrophthalmus* were mature at about 130 mm. The same result was obtained by ova diameter studies also. Weight at first maturity was about 35 gms. The reproductive load which has great bearing on the reproductive potential of fishes was also calculated and it was found to be 0.562 for the years 1968 and 1969. The relationships between ova diameter and relative ovary weight and ova diameter and total length were also determined. The fecundity of the species ranged from 13,405 to 44,167 and the mean fecundity was found to be 30,207. The relationships between fecundity and total length, fecundity and weight of fish, fecundity and weight of ovary and weight of ovary and length of ovary were also studied. Sex ratio of the fish was analysed by X^2 - test to find out whether the variation between years and various size groups differed significantly at 5% level. The ratio did not differ between years but the length groups below 124 mm deviated from 1:1 ratio significantly at 5% level. Males were dominant in this group.

Age and growth of P. macrophthalmus were investigated. A linear relationship was observed between otolith length and total length and scale length. Markings or the rings in the otoliths were not found to be related to age of fish. Growth in length was analysed by Petersen's method and probability plot method. The species attained a total length of about 132 mm at the end of first year, 195 mm at the end of second year and 202 mm at the end of two and half years. Growth curves were fitted with von Bertalanffy's equation by employing both arithmetic method and graphical methods. Growth parameters were obtained by Gompertz equation also. Both equations provided fairly good fit to the growth data and the correlation coefficient ('r') for the von Bertalanffy's equation was nearer to unity than in Gompertz equation. The asymptotic length was found to be 239.46 mm by theoritical method and 240 mm by the graphical method. Growth in weight was also determined by an equation analogous to that of von Bertalanffy and Gompertz equations. It was observed that the *P. macrophthalmus* attained 30 gm, 105 gm and 128 gm at the end of first year, second year and two and half years respectively. The equations gave good fit to the data.

Morphometric characters like head length, snout length, eye diameter, pectoral fin length and second anal spine length were studied in relation to total length. The differences in these characters of the samples from various localities were studied by analysis of covariance. It was observed that head length and pectoral length were significant at 5% level between the samples from Palk Bay and Coromandal coast whereas eye diameter was highly significant at 5% level between samples from these two areas. These characters are found to be non-significant at 5% level between samples from Madras and Kakinada indicating that they belong to the same stock. Hence it can be concluded that the Palk Bay stock is racially distinct from that of Coromandal stock.

Species composition of sciaenids differs from one place to another. This difference is marked in the sciaenids of east and west coasts. *Otolithes ruber* which forms fishery along east

Coast does not form a fishery in west coast. Similarly *Otolithes cuvieri* which forms a fishery along west coast does not occur commonly in east coast. Species composition of sciaenids at Mandapam and their seasonal variation have also been studied. The common fishing gears and craft employed are described along with the details of the mechanised boats. The fishing seasons for sciaenids along Indian coast have been discussed. The catch statistics of sciaenid fishes for the last 13 years show that the sciaenids contributed about 4% of the total annual marine fish landings in India. The total sciaenid landings of India have increased from 29,822 tonnes in 1950 to 39,099 tonnes in 1972. The total sciaenid catches of west coast are much higher (29,943 tonnes) than those of the east coast (16,156 tonnes). The gas bladder of sciaenids are exported to Far-Eastern countries where it is used for the purification of wine.

Gonads of *Pennahia macrophthalmus* are infested by a nematode parasite *Philometra filamentosa* sp. nov. which causes damage to the ovary. Another nematode parasite *Philometra nairii* sp. nov. is described from the fins of *Pennahia macrophthalmus*.

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L E G E N D

PLATE I

Fig. 1. a. *Johnius carutta* Bloch. T.L. 180 mm.
b. Otoliths
c. Gas bladder

2. a. *Johnius glaucus* (Day). T.L. 185 mm.
b. Otoliths

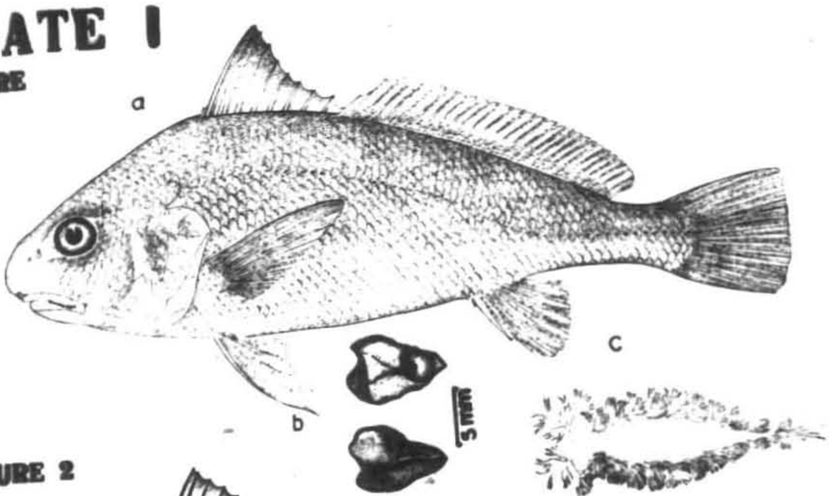
3. a. *Johnius coitor* (Hamilton). T.L. 172 mm.
b. Otoliths

4. a. *Johnius mannarensis* Mohan. T.L. 190 mm.
b. Gill rakers
c. Otoliths
d. Lower jaw

1. Maxillary pores
2. Marginal pores
3. Inner mental pore
4. Outer mental pore
5. Median mental pore
6. Mental barbel

PLATE I

FIGURE



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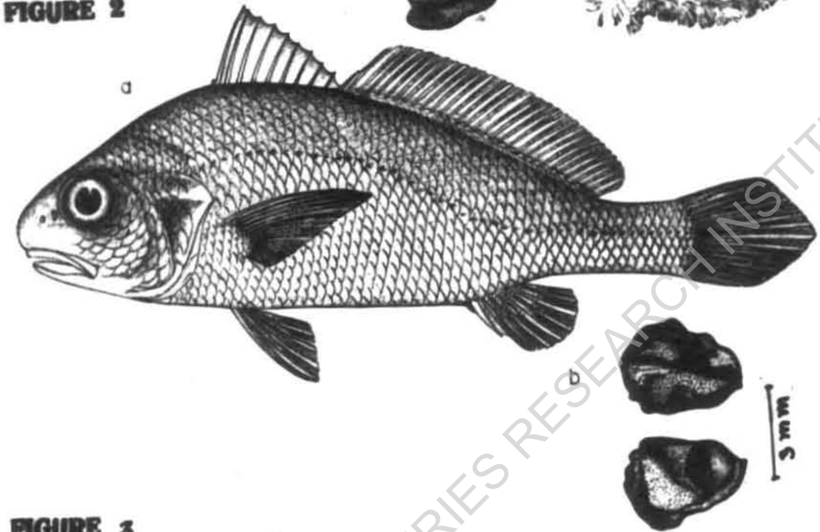


FIGURE 3

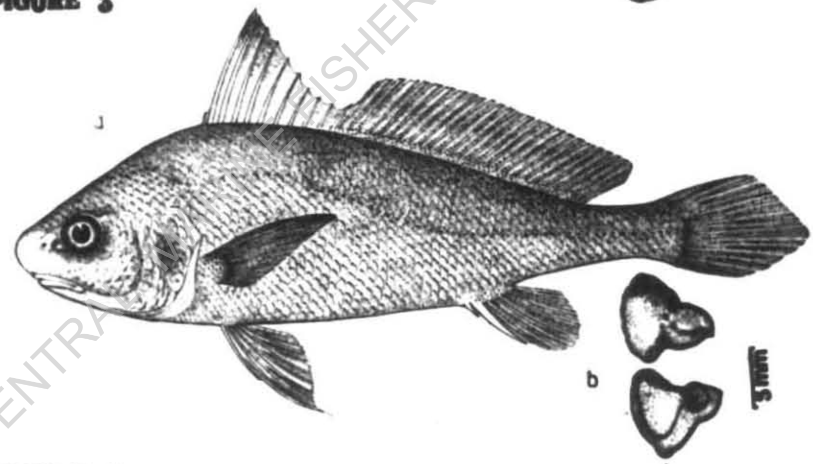


FIGURE 4

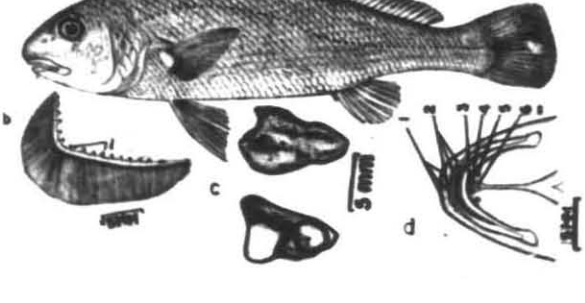


PLATE II

Fig. 1. a. *Johnius macropterus* (Bleeker). T.L. 135 mm.
b. Otoliths

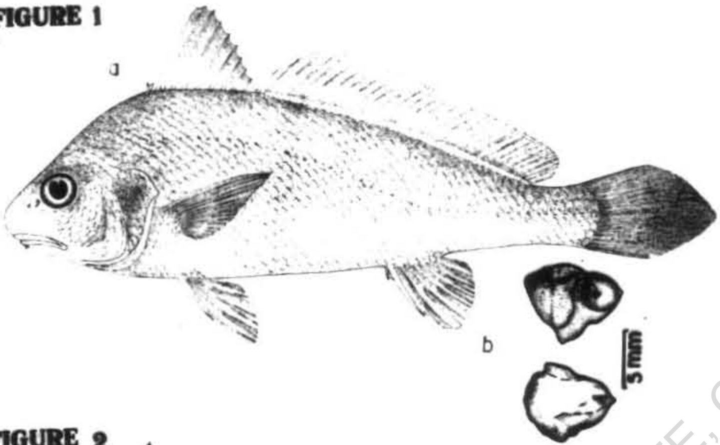
2. a. *Johnius belangerii* (Cuvier). T.L. 185 mm.
b. Otoliths

3. a. *Johnius carouna* (Cuvier). T.L. 177 mm.
b. Otoliths

4. a. *Johnius dussumieri* (Valenciennes). T.L. 166 mm.
b. Otoliths

PLATE II

FIGURE 1



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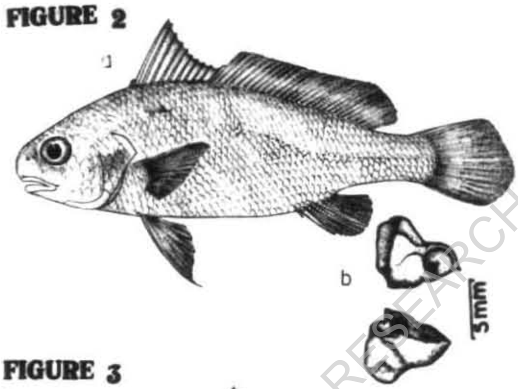

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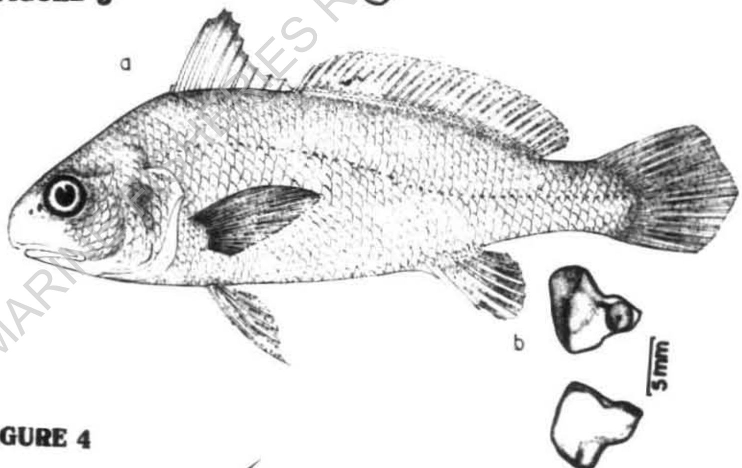

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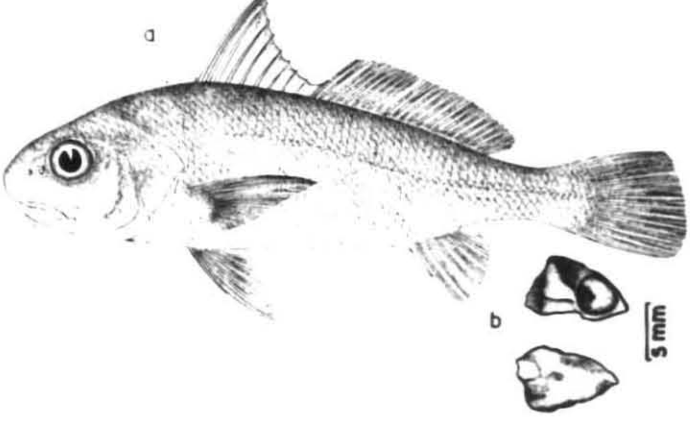


PLATE III

Fig. 1. a. *Johnius elongatus* Mohan. T.L. 175 mm.
b. Otoliths

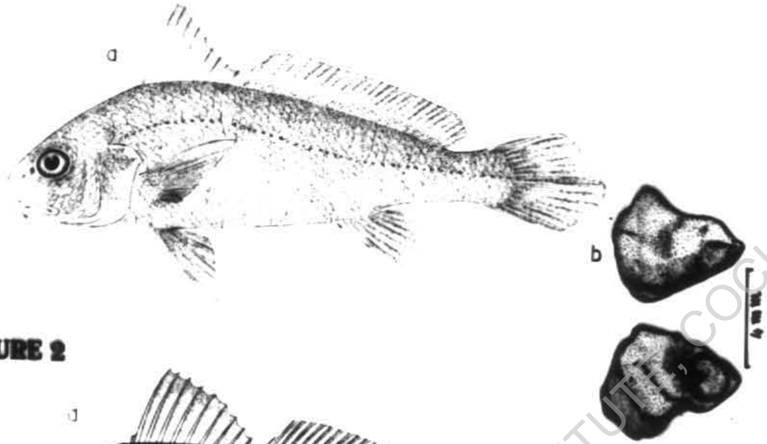
2. a. *Johnieops vogleri* (Bleeker). T.L. 145 mm.
b. Otoliths

3. a. *Johnieops osseus* (Day). T.L. 130 mm.
b. Otoliths

4. a. *Johnieops sina* (Cuvier). T.L. 195 mm.
b. Otoliths

PLATE III

FIGURE



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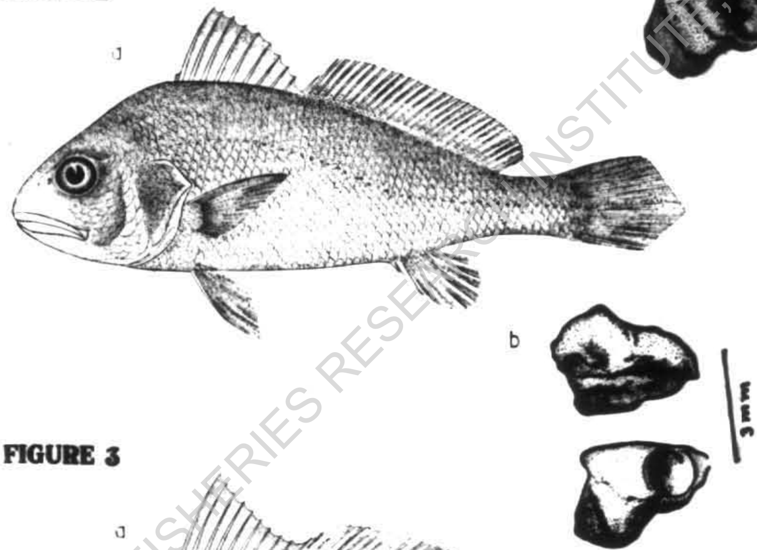

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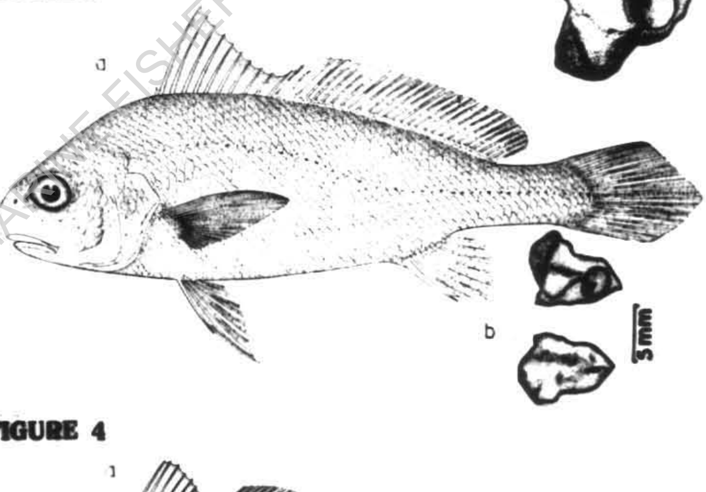

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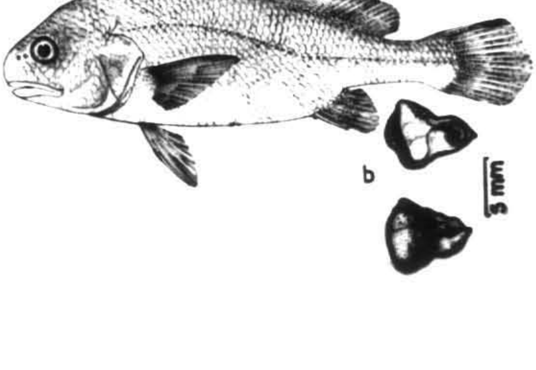


PLATE IV

Fig. 1. a. Johnieops macrorhynus Mohan. T.L. 133 mm.
b. Otoliths

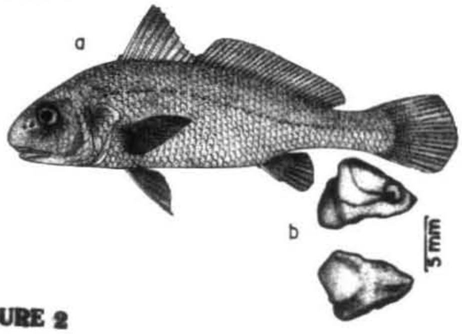
2. a. Kathala axillaris (Cuvier). T.L. 150 mm.
b. Otoliths

3. a. Macrospinosa cuja (Hamilton). T.L. 285 mm.
b. Otoliths

4. a. Otolithoides biaurites (Cantor). T.L. 172 mm.
b. Otoliths

PLATE IV

FIGURE 1



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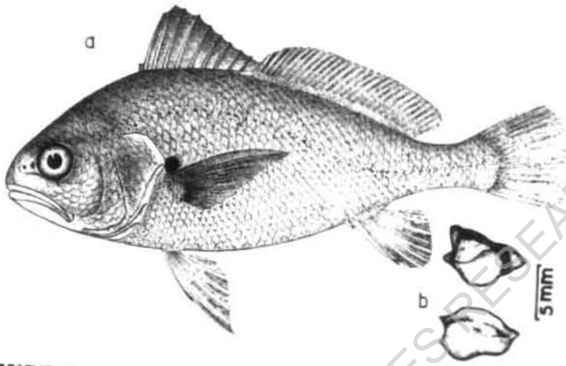

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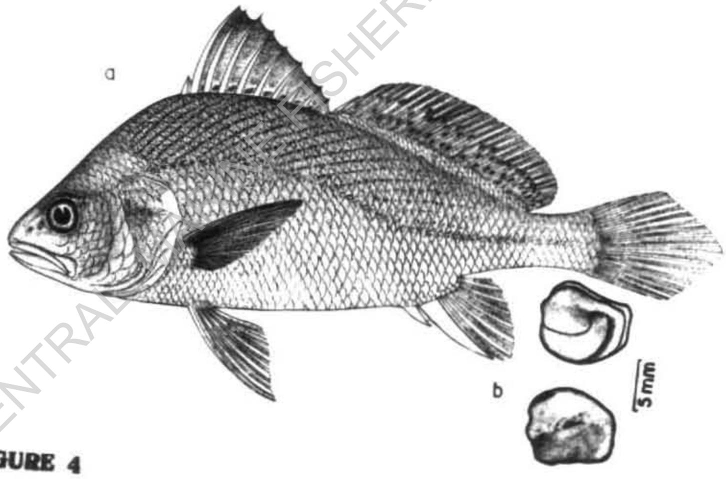

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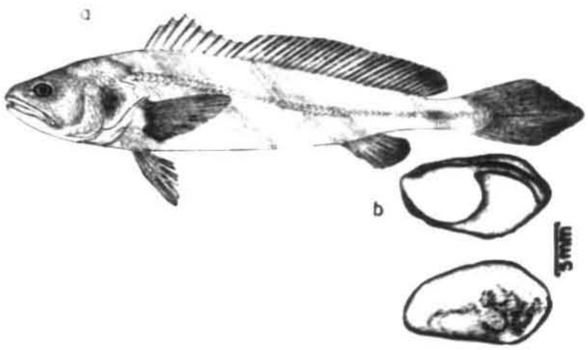


PLATE V

Fig. 1. a. Otolithoides pama (Hamilton). T.L. 162 mm.
b. Gill rakers
c. Lower jaw
d. Otoliths

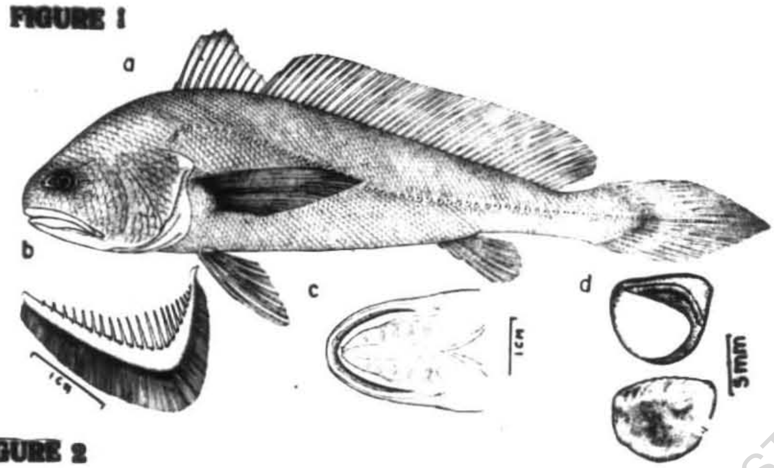
2. a. Panna microdon (Bleeker). T.L. 205 mm.
b. Gill rakers
c. Otolith

3. a. Pterotolithes maculatus (Cuvier). T.L. 130 mm.
b. Gill rakers
c. Otoliths

4. a. Otolithes ruber (Schneider) T.L. 215 mm.
b. Gill rakers
c. Lower jaw
d. Otoliths

PLATE V

FIGURE 1



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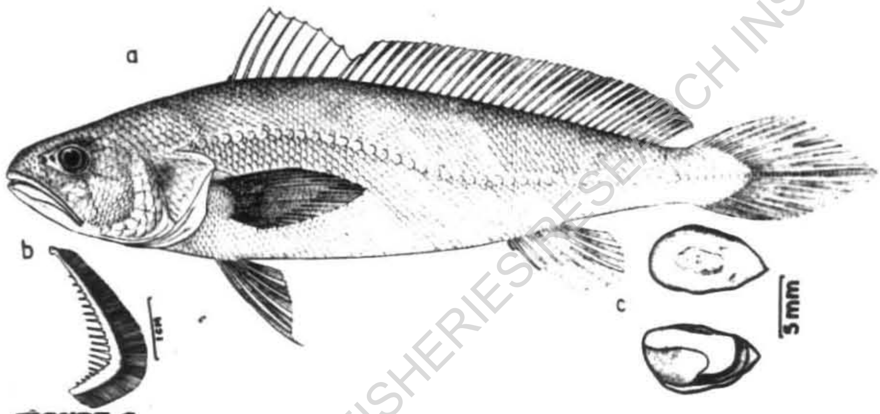

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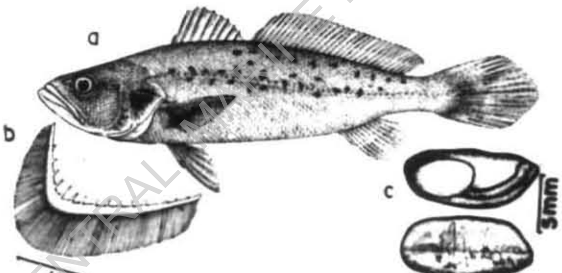

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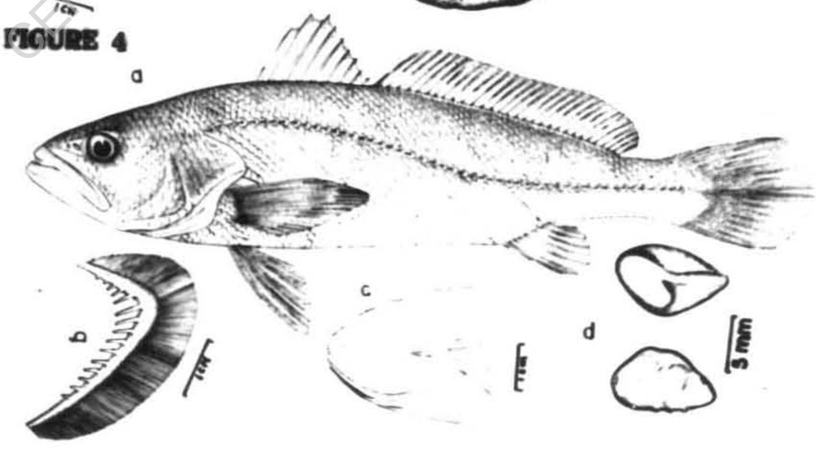


PLATE VI

Fig. 1. a. <u>Otolithes cuvieri</u> (Schneider). T.L. 215 mm.
b. Otoliths
c. Lower jaw

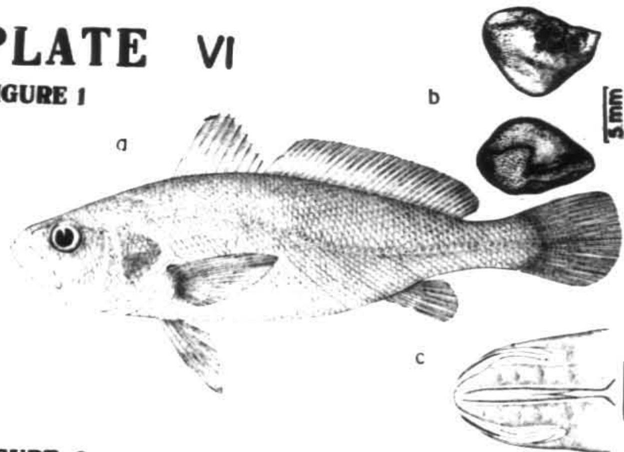
2. a. <u>Chrysochir aureus</u> (Richardson). T.L. 245 mm.
b. Otoliths

3. a. <u>Nibea soldado</u> (Lacepede) T.L. 205 mm.
b. Otoliths
c. Gas bladder

4. a. <u>Nibea albida</u> (Cuvier). T.L. 144 mm.
b. Otoliths
c. Ventral view of head

PLATE VI

FIGURE 1



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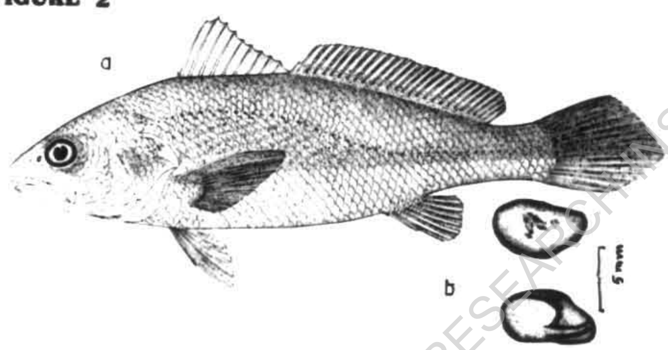

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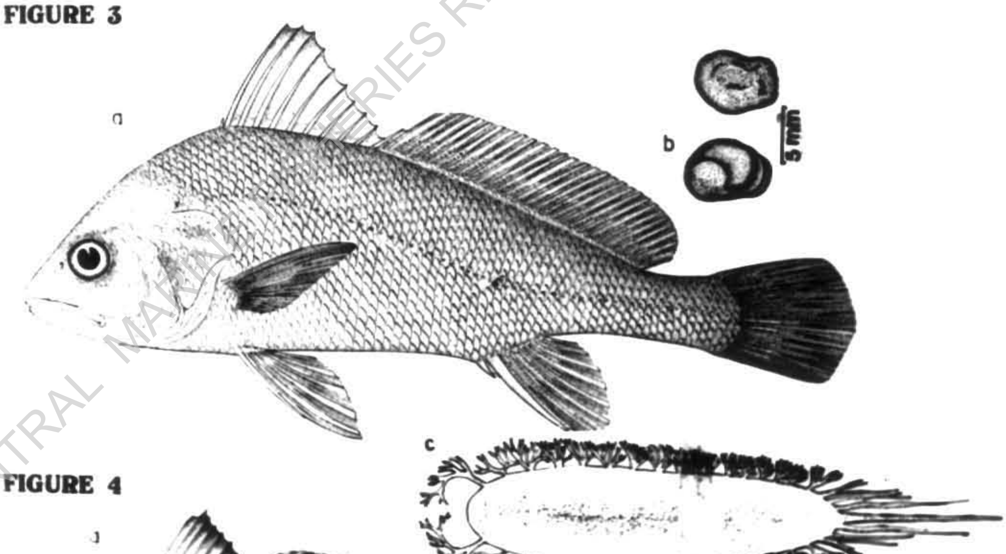

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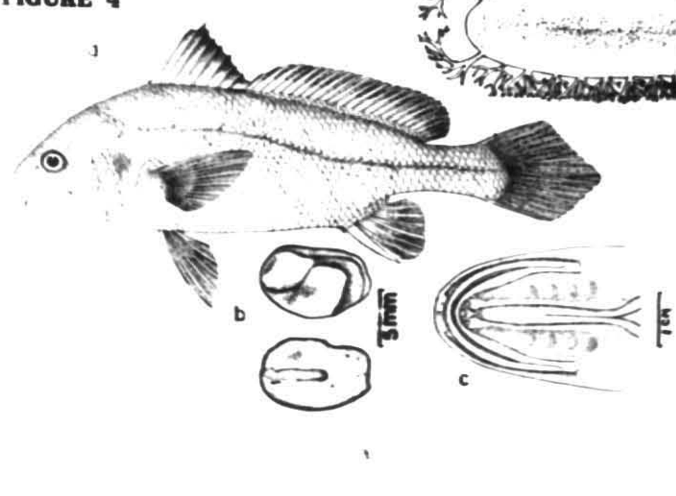


PLATE VII

Fig. 1. a. Nibea semiluctuosa (Cuvier). T.L. 217 mm.
b. Otoliths

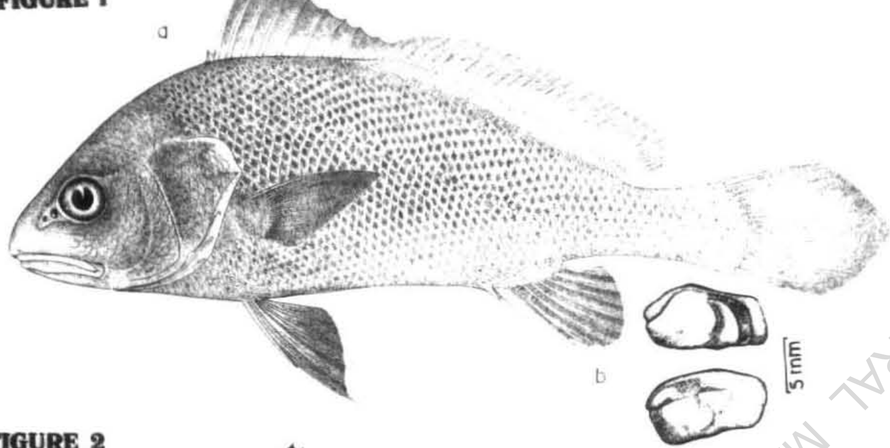
2. a. Nibea diacanthes (Lacepede). T.L. 210 mm.
b. Otoliths

3. a. Nibea maculatus (Schneider). T.L. 230 mm.
b. Otoliths

4. a. Dendrophysa russelli (Cuvier). T.L. 145 mm.
b. Otoliths
c. Gas bladder

PLATE VII

FIGURE 1



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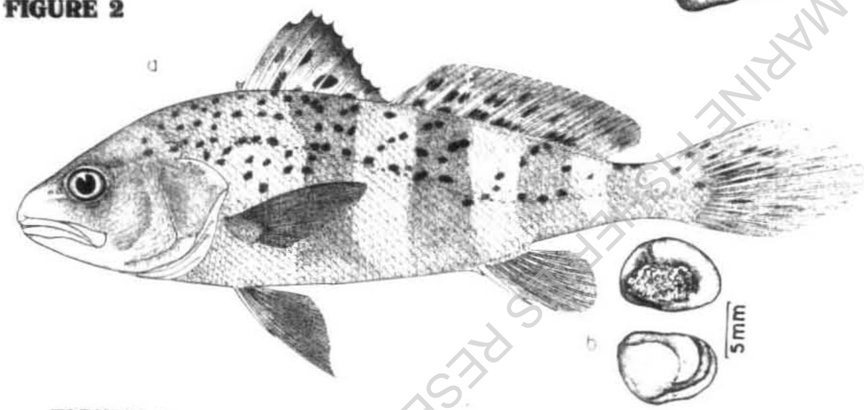

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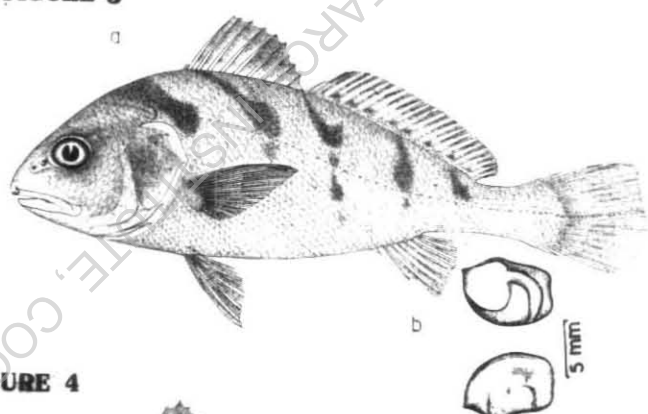

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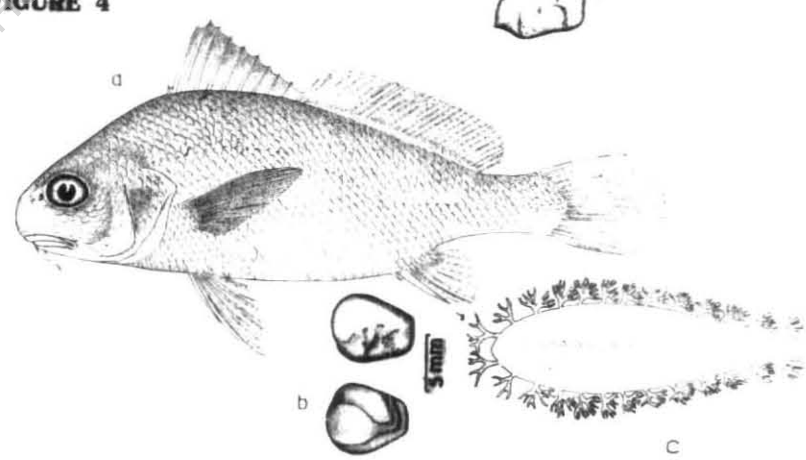


PLATE VIII

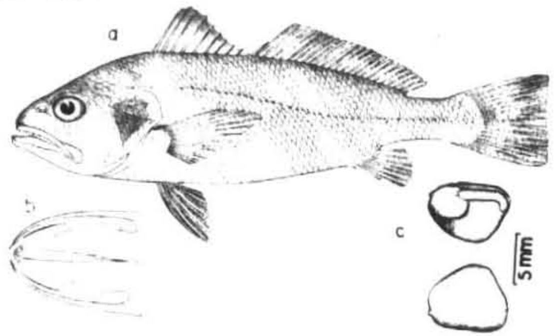
Fig. 1. a. <u>Pennahia macrophthalmus</u> (Bloch). T.L. 162 mm.
b. Ventral view of head
c. Otoliths

2. a. <u>Atrobucca nibe</u> (Jordan and Thompson) T.L. 160 mm.
b. Otoliths

3. Phylogenitic dagram of the Family Sciaenidae of India

PLATE VIII

FIGURE 1



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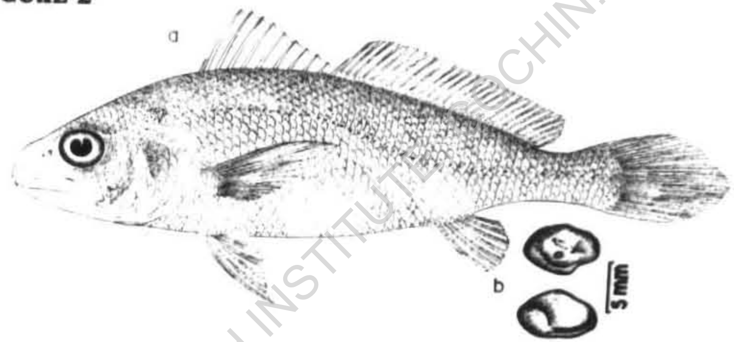

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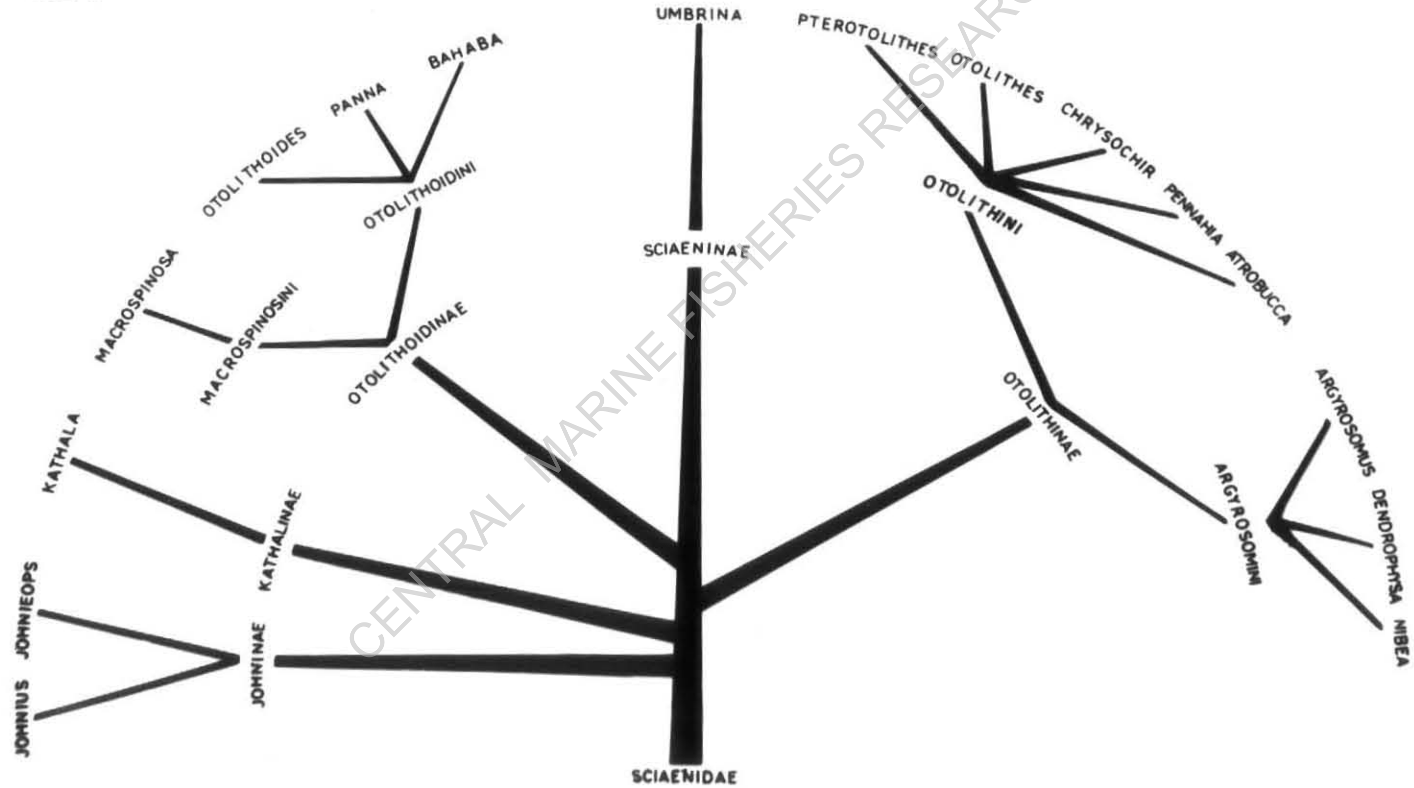


PLATE IX

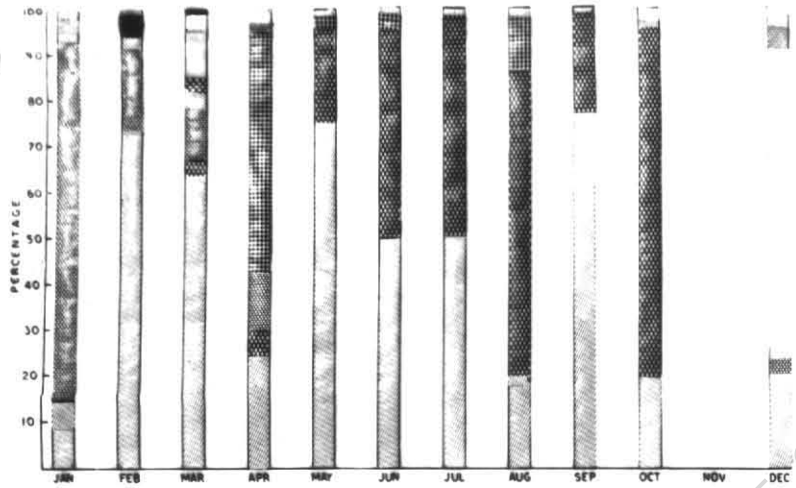
Fig. 1. Histogram of the food of *Pennahia macrophthalmus* during 1968

2. Histogram of the food of *Pennahia macrophthalmus* during 1969

3. Histogram of the food of various length groups of *Pennahia macrophthalmus* during 1968 and 1969

PLATE IX

FIGURE 1



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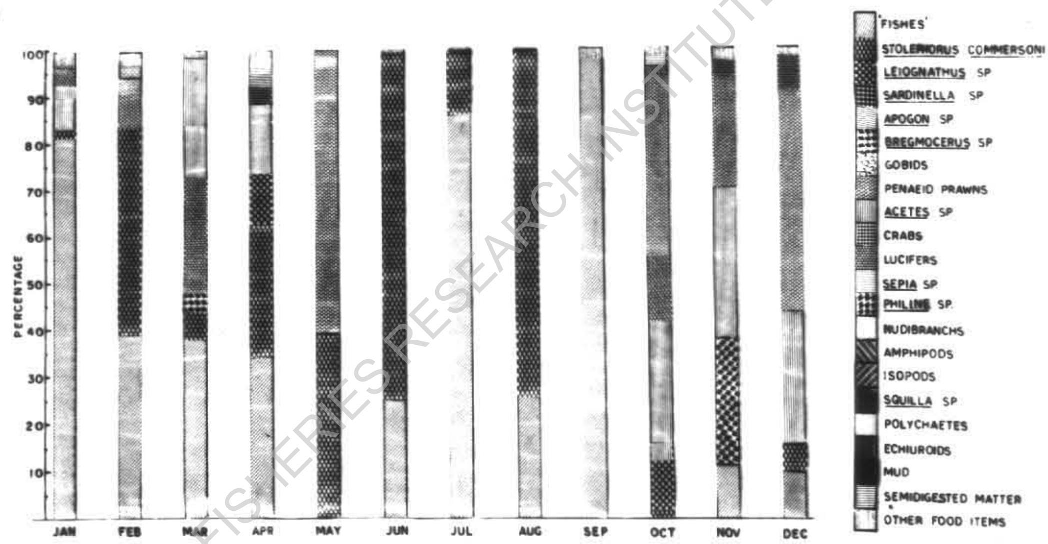


FIGURE 3

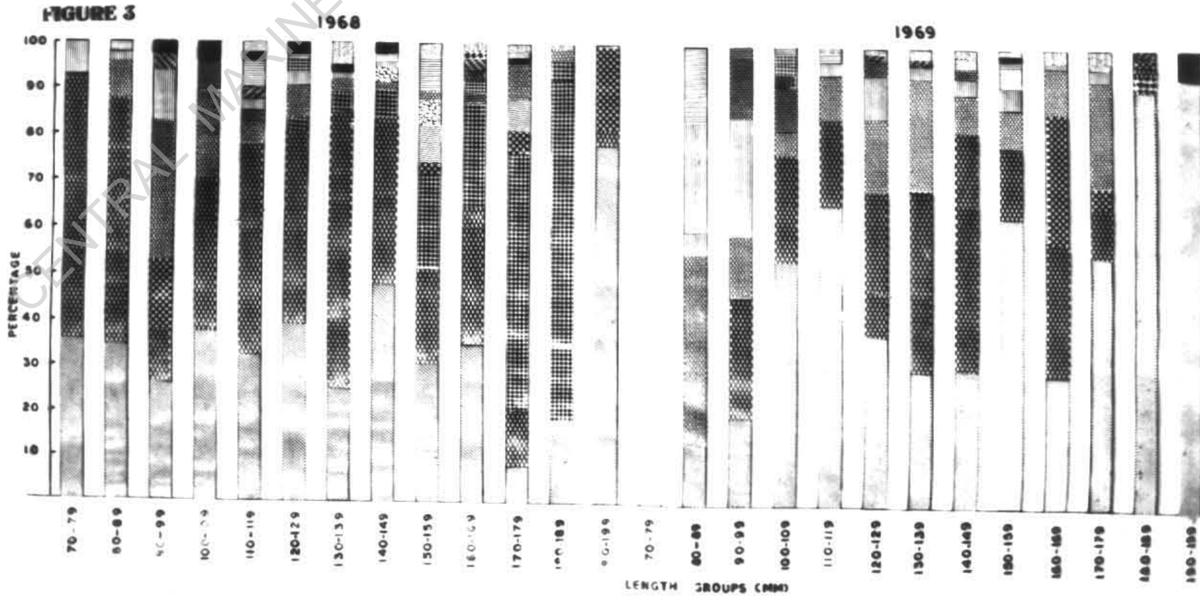


PLATE X

Fig. 1. Histogram of empty stomachs in various length groups of *Pennahia macrophthalmus*.

2. Histogram of condition of stomachs during the years 1968 and 1969.

PLATE X

FIGURE 1

PERCENTAGE OF EMPTY STOMACH IN DIFFERENT SIZE GROUPS

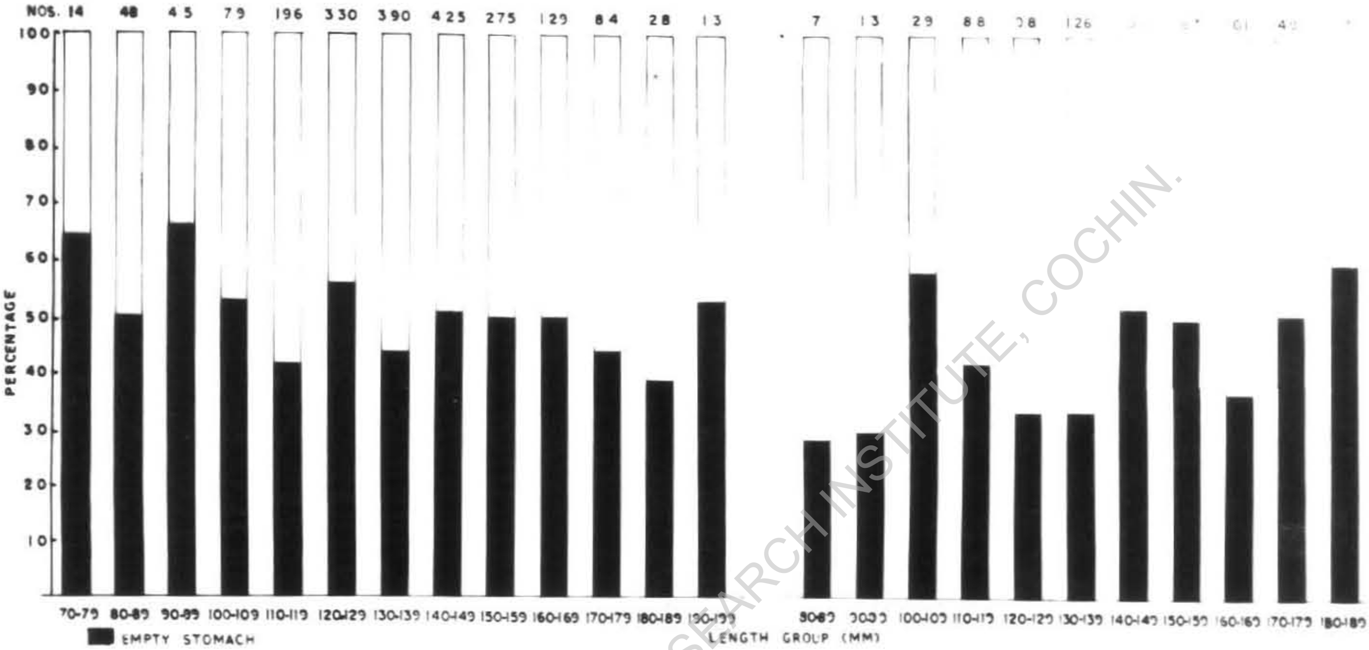


FIGURE 2

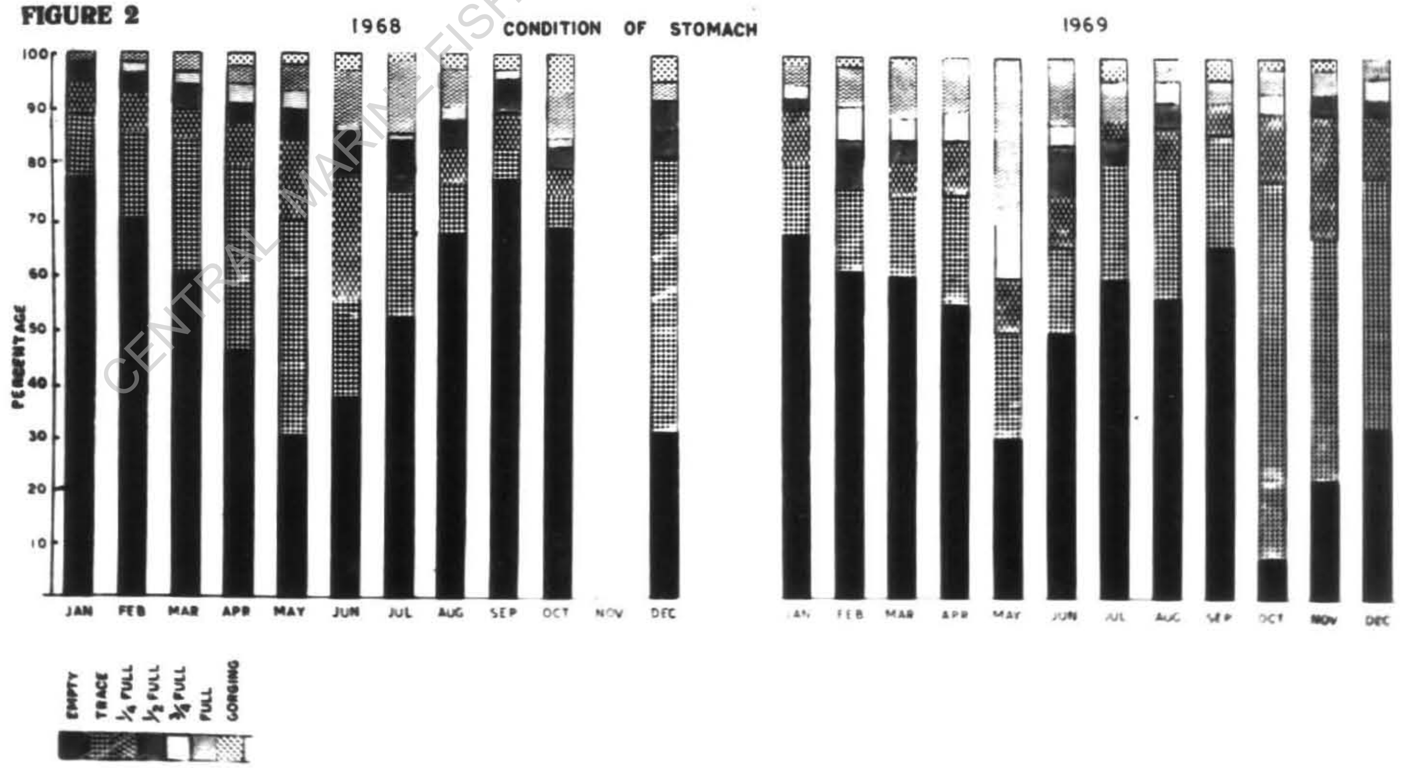


PLATE XI

Fig. 1. Logarithmatic relation of length and weight of _Pennahia macrophthalmus_ (male).

2. Logarithmatic relation of length and weight of _Pennahia macrophthalmus_ (female)

3. Length-weight relationship of male and female

4. Relative condition factor of mature and immature specimens during 1968

5. Relative condition factor of mature and immature specimens during 1969

6. Relation of length and weight of ovaries (Mature and immature)

PLATE XI

FIGURE 1

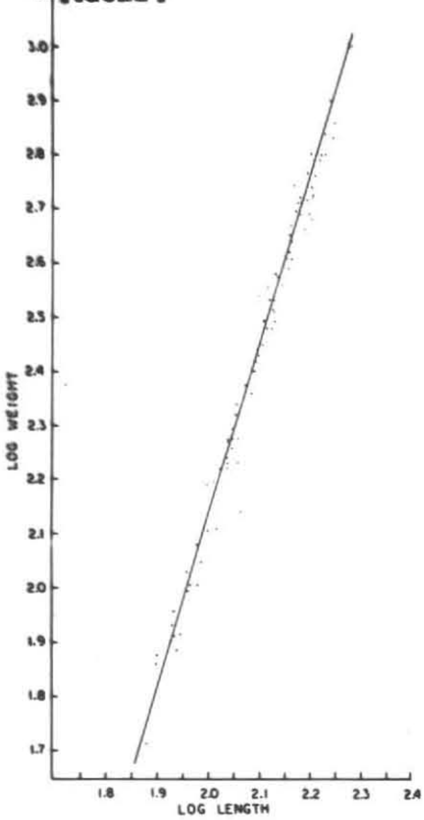


FIGURE 3

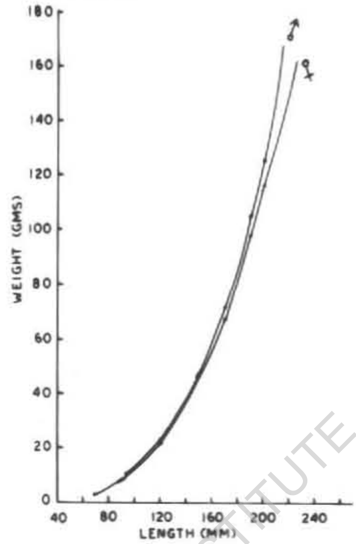


FIGURE 4

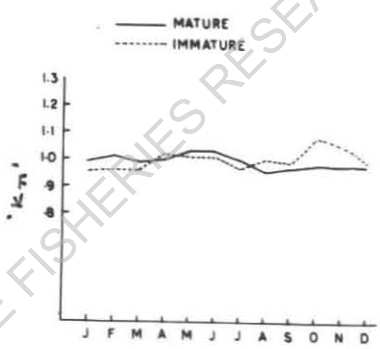


FIGURE 5

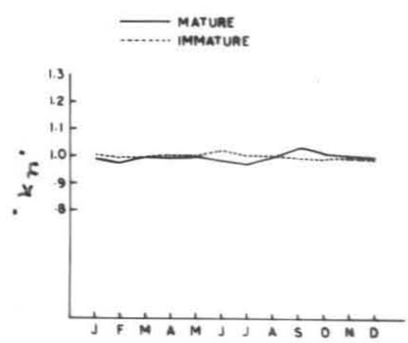


FIGURE 2

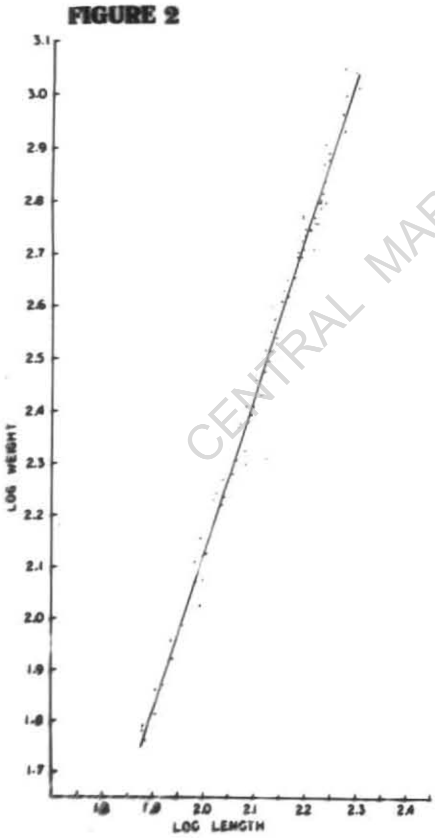


FIGURE 6

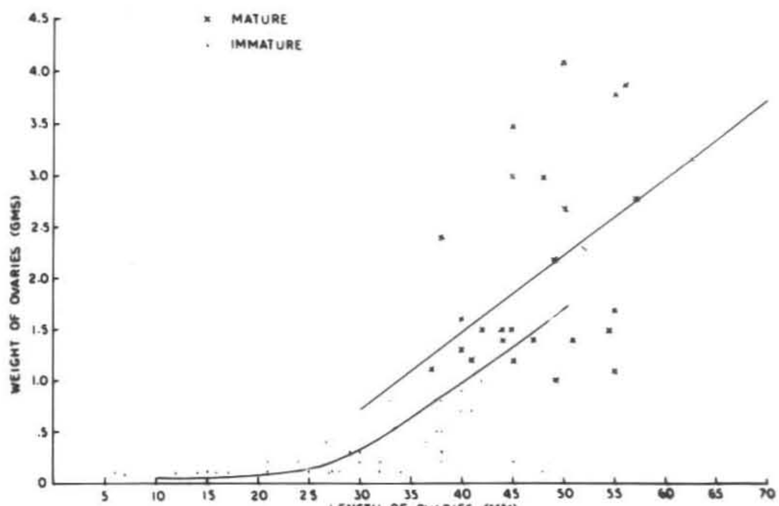


PLATE XII

Fig. 1. Ova diameter frequency polygon of *Pennahia macrophthalmus* (1 M.D. = 0.02 mm)

2. Gonadosomatic index of *P. macrophthalmus* for 1968 and 1969.

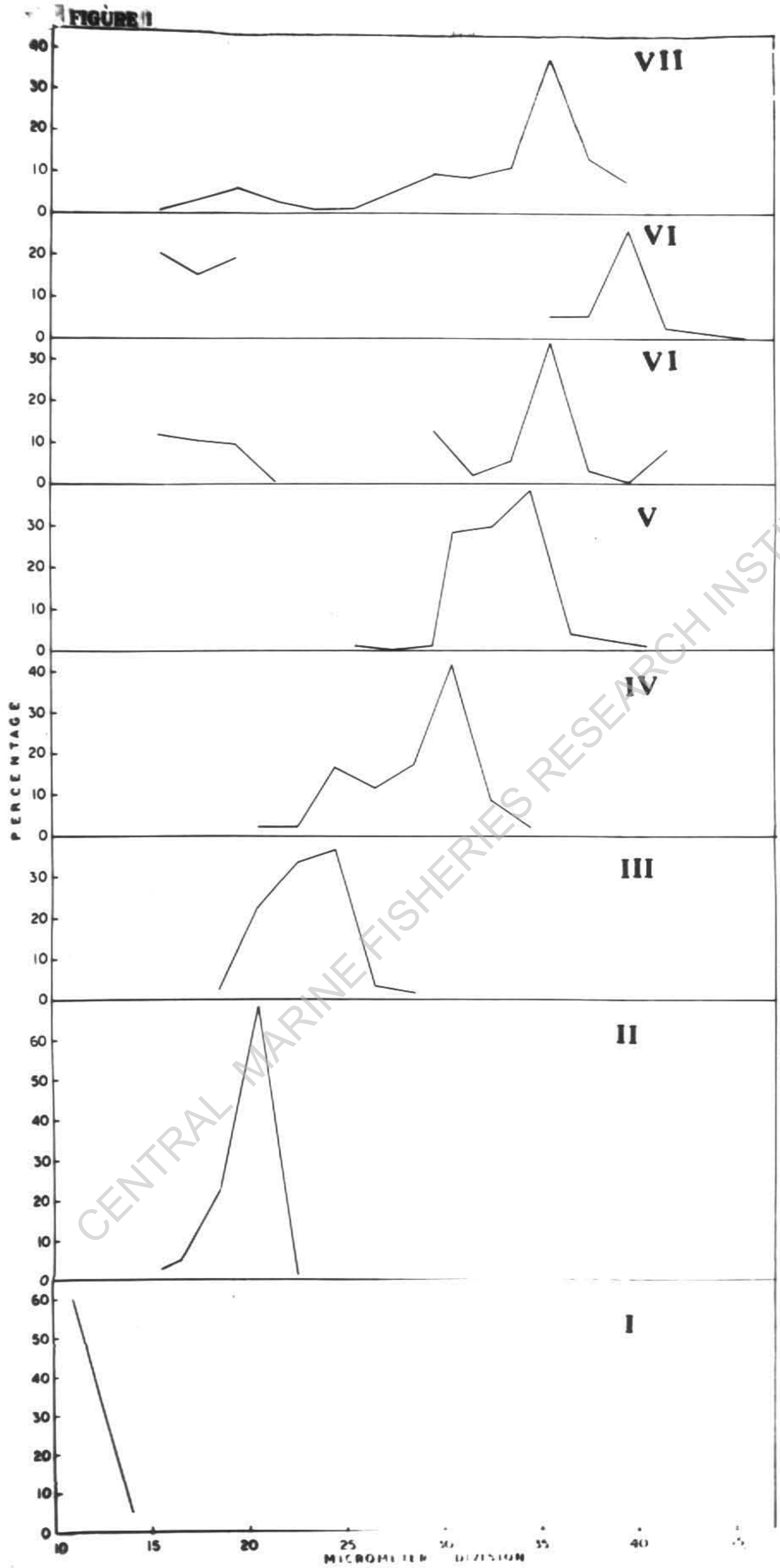
3. Ova diameter frequency polygon of left and right ovaries (Pooled)

4. Ovadiameter frequency polygon of left and right ovaries.

5. Ova diameter frequency polygon of upper, middle and lower portion of a mature ovary.

PLATE XII

FIGURE 1



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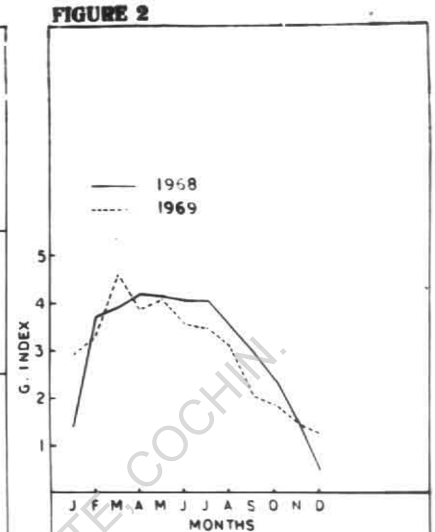

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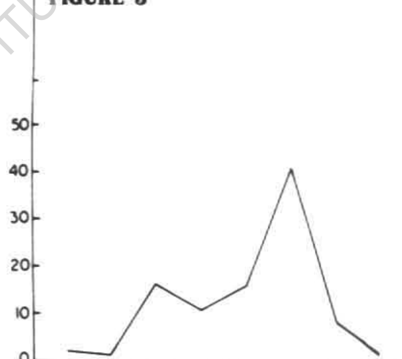


FIGURE 4

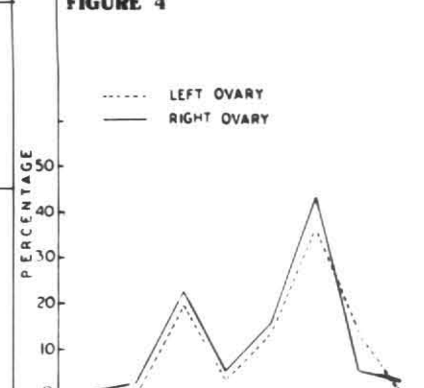


FIGURE 5

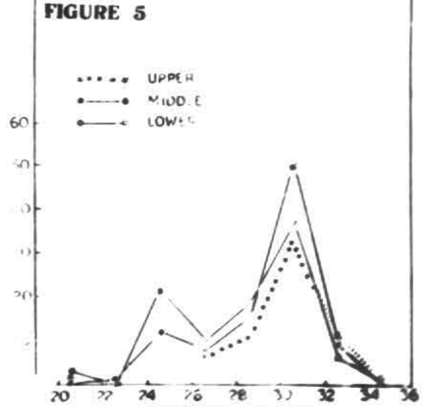


PLATE XIII

Fig. 1. Histogram of maturity stages of ovaries in 1968 and 1969

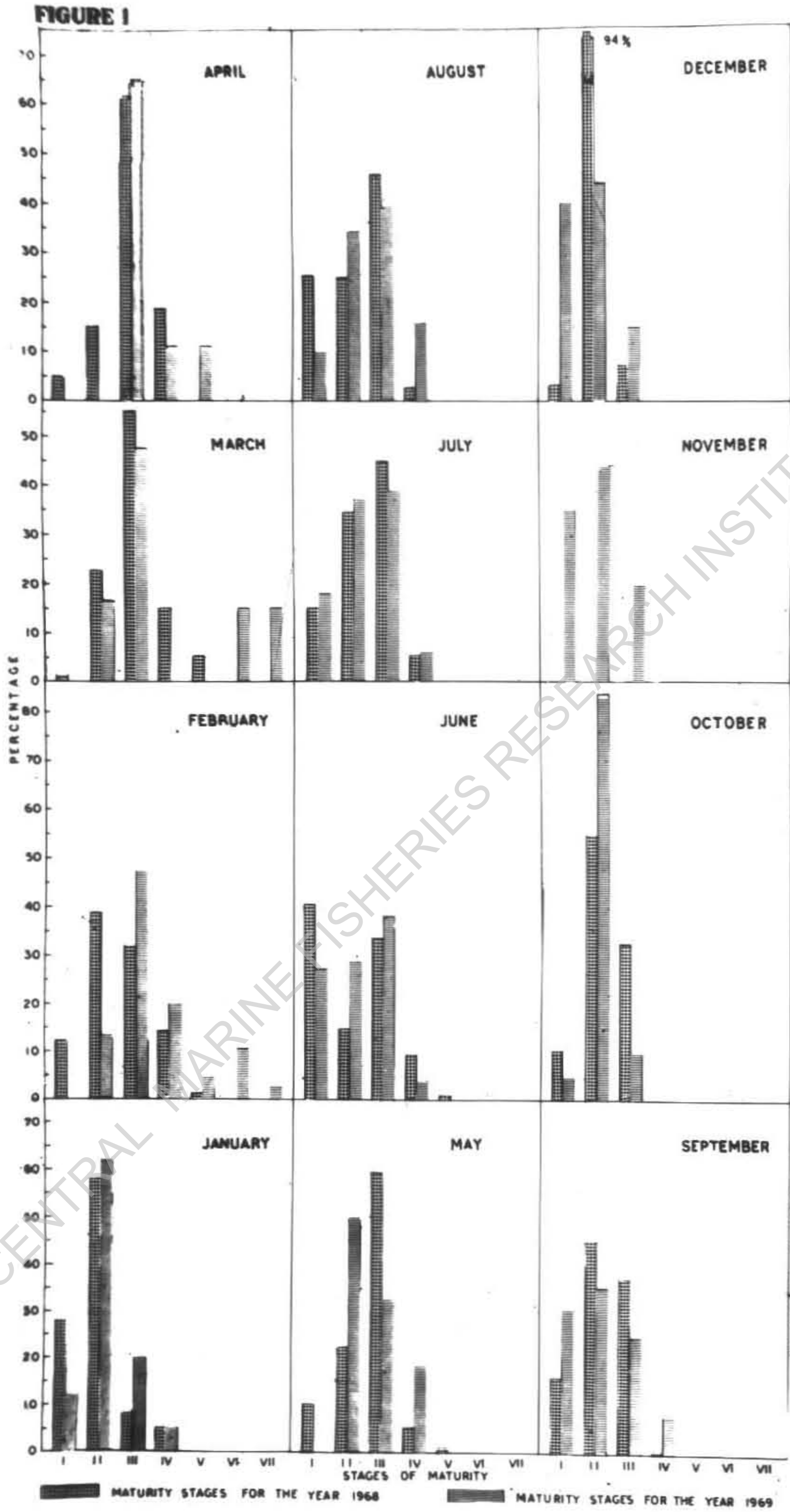
2. Relation between length of ovaries and the length of fishes

3. Relation between length of testes and length of fish

4. Relation between ova diameter and total length of fish. (1 M.D. = .02 mm)

PLATE XIII

FIGURE 1



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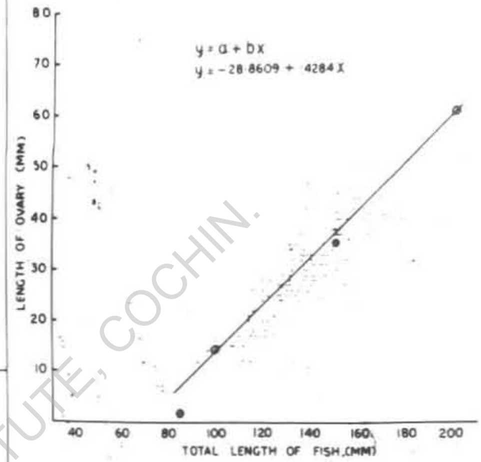


FIGURE 3

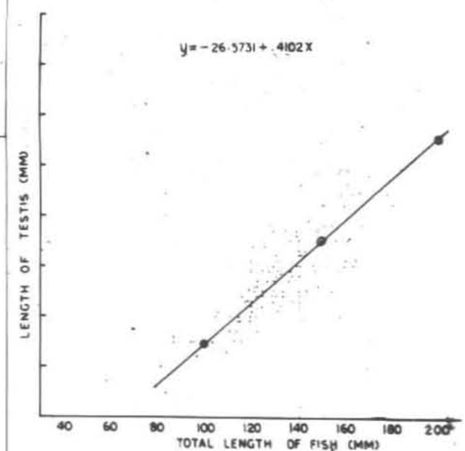


FIGURE 4

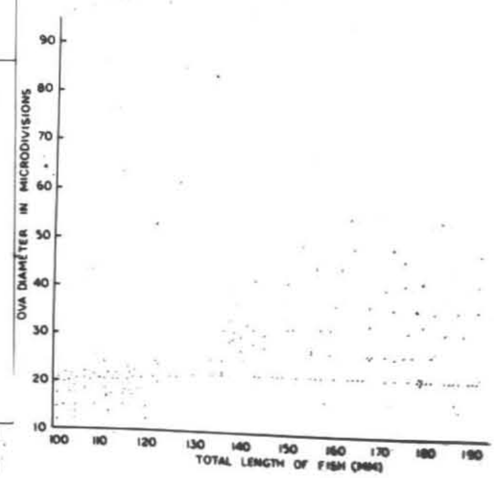


PLATE XIV

Fig. 1. Length at first maturity, 1968
2. Length at first maturity, 1969
3. Length at first maturity for the pooled data for the years 1968 and 1969
4. Relation between fecundity and weight of ovaries
5. Relation between fecundity and weight of fish
6. Relation between fecundity and total length of fish
7. Relation between ova diameter (model value) and relative ovary weight X 10^3
8. Relation between weight of fish and relative ovary weight X 10^3

PLATE XIV

FIGURE 1

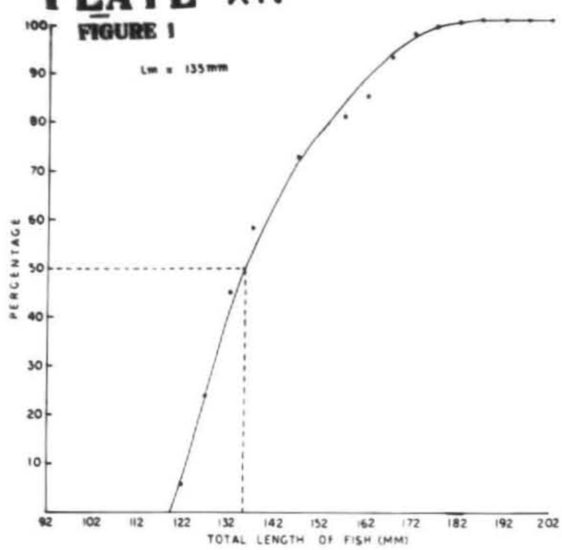


FIGURE 2

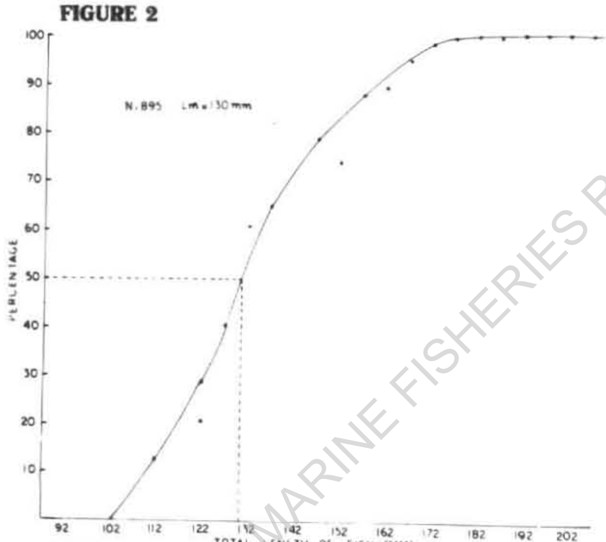


FIGURE 3

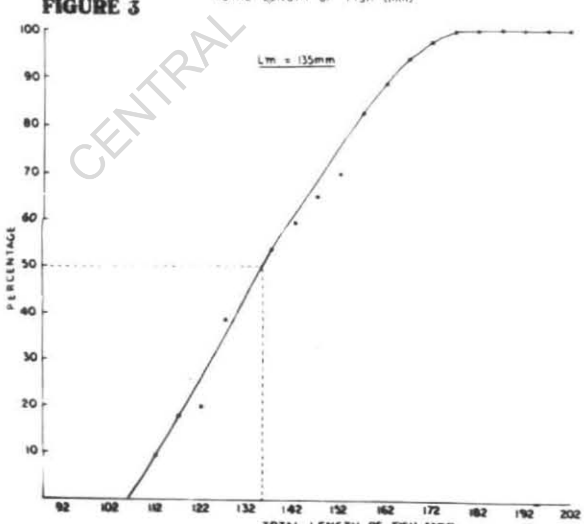


FIGURE 4

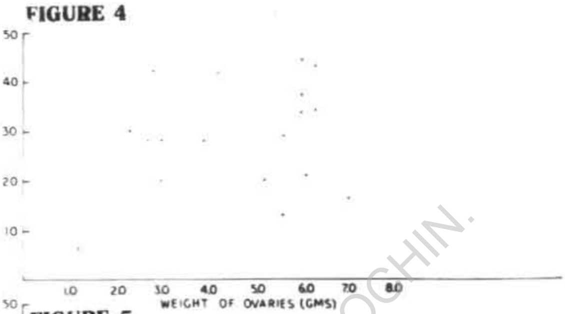


FIGURE 5

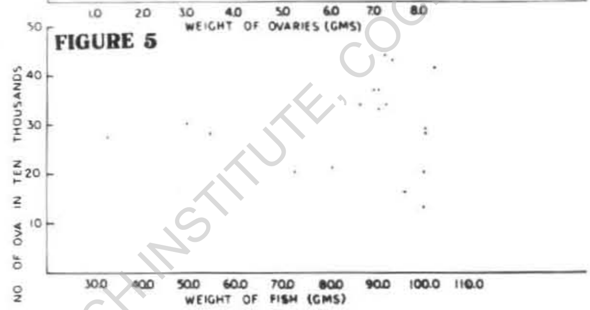


FIGURE 6

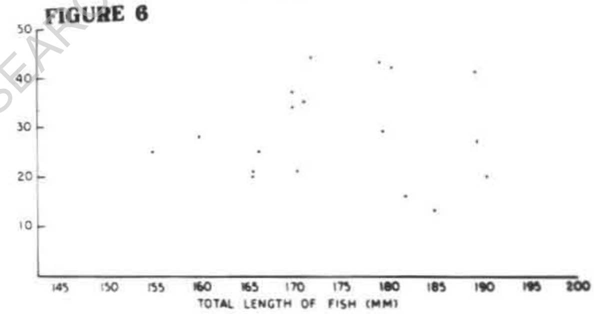


FIGURE 7

FIGURE 8

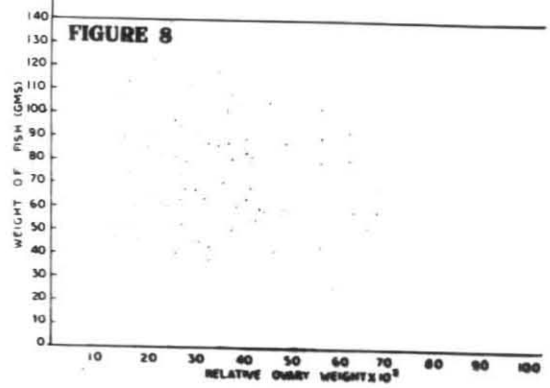


PLATE XV

Fig. 1. Length-frequency histogram of

Pennahia macrophthalmus.

PLATE XV

FIGURE 1

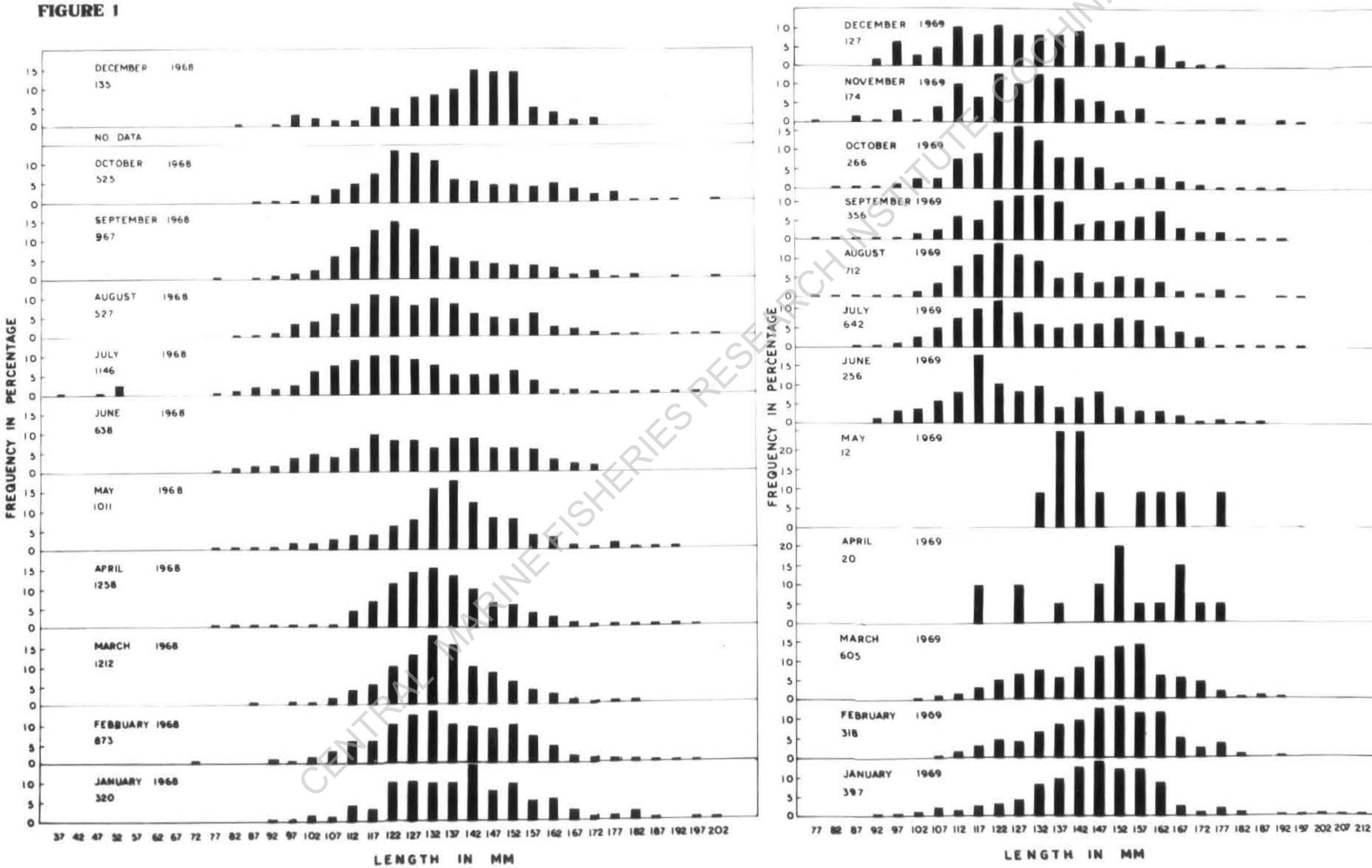


PLATE XVI

Fig. 1. Probability plot chart for the determination of growth for the year 1968

2. Probability plot chart for the determination of growth for the year 1969

3. Probability plot chart for the pooled data for the years 1968 and 1969

4. Ford - Walford graph

5. $\text{Log}_e (L_\infty - L_t)$ plotted against the age t to find 't_o'

6. Growth curves of *Pennahia macrophthalmus* using various growth formulae.

PLATE XVI

FIGURE 1

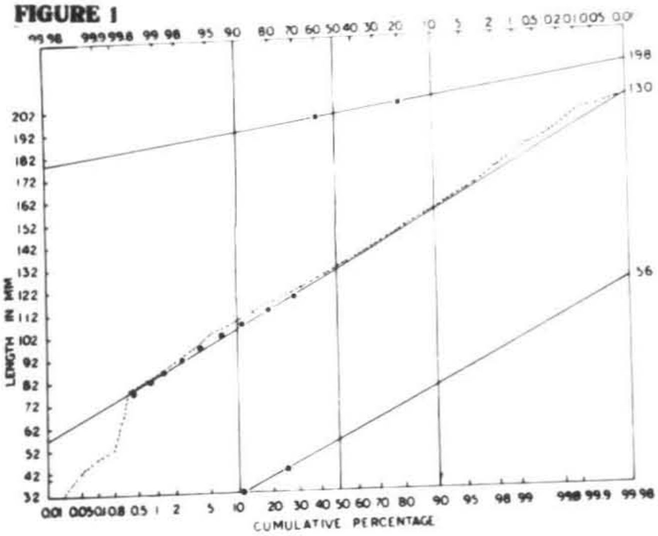


FIGURE 4

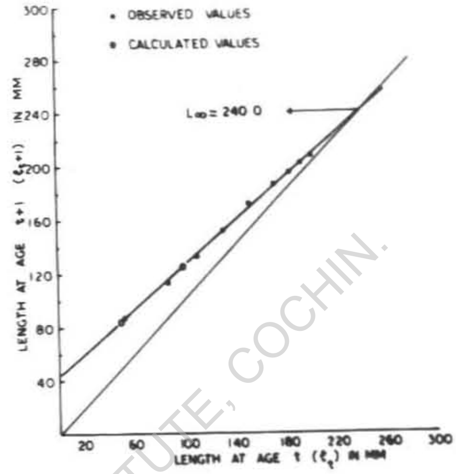


FIGURE 2

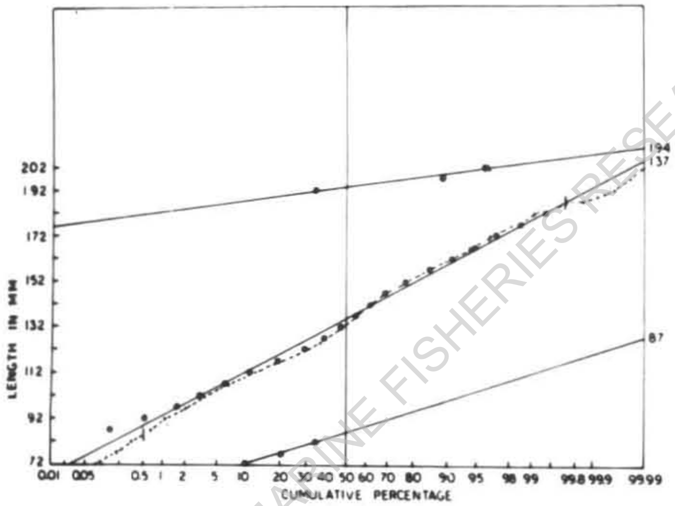


FIGURE 5

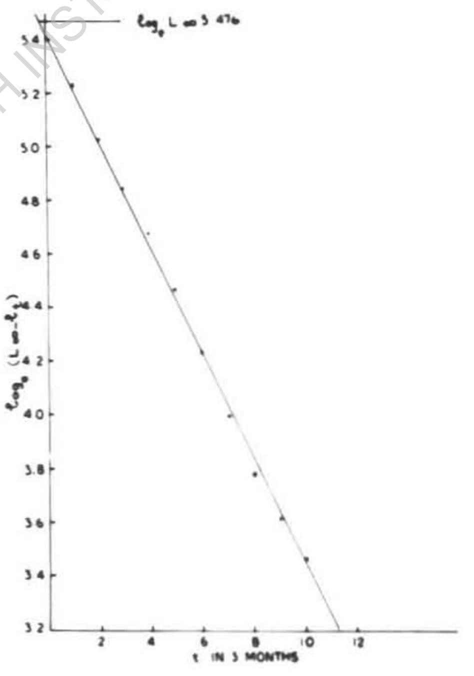


FIGURE 3

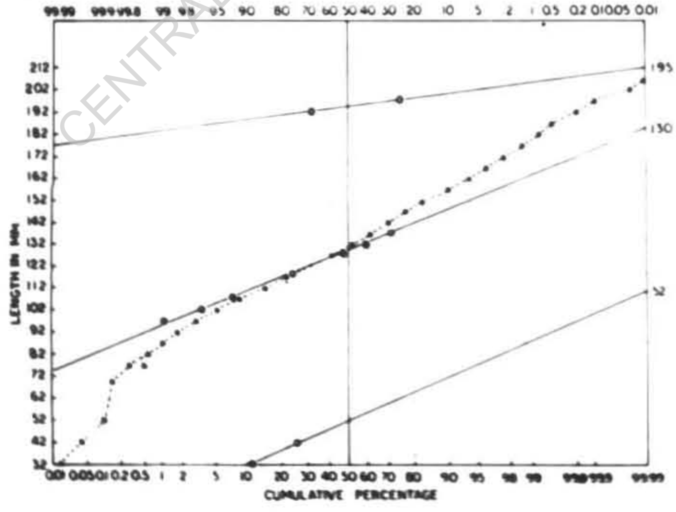


FIGURE 6

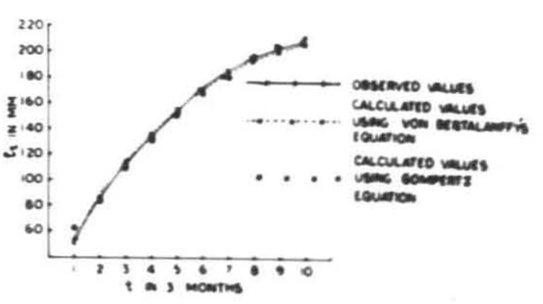


PLATE XVII

Fig. 1. Histogram of yearly increment of growth in length

2. Histogram of yearly increment of growth in weight

3. $\mathrm{Log}_e\ (W_\infty^{1/3} - W_t)$ plotted 't' to find 't_o'

4. Growth in weight for observed and calculated values (von Bertalanffy's equation)

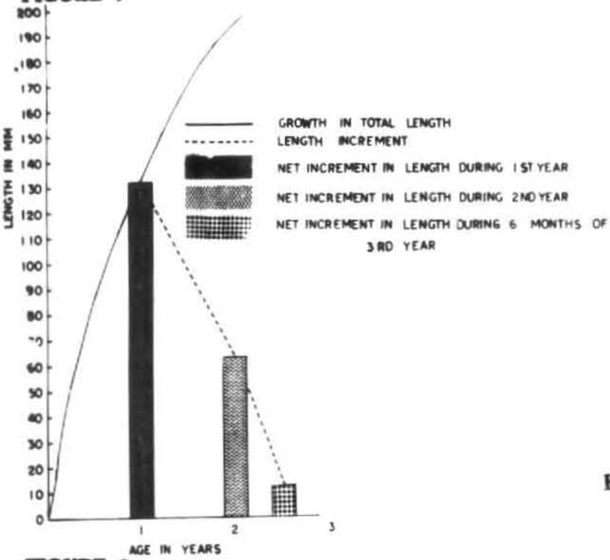
5. Ford-Walford graph of weight to determine W .

6. Growth in weight for observed and calculated (Compertz equation) values.

7. Relation between total length-head length, total length-pectoral length, and total length-eye diameter.

PLATE XVII

FIGURE 1



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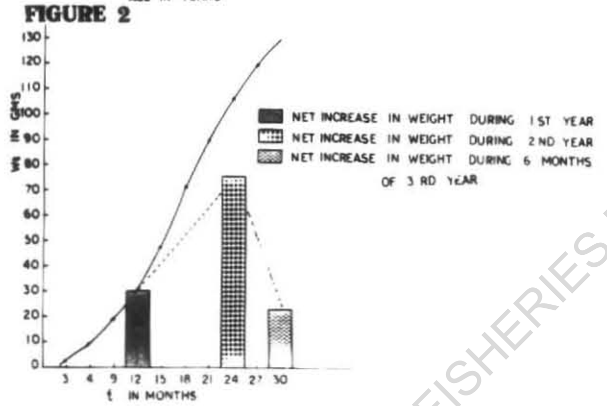

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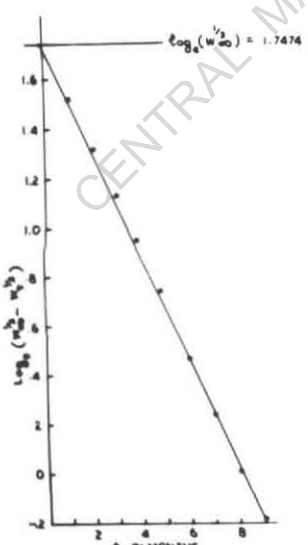

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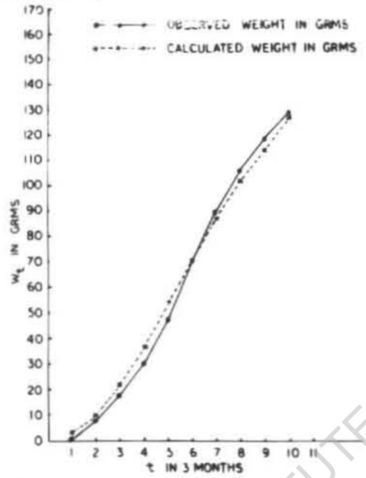
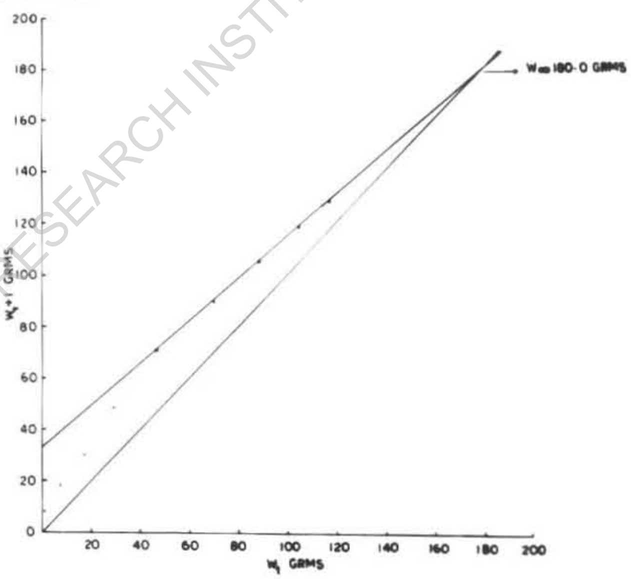


FIGURE 5



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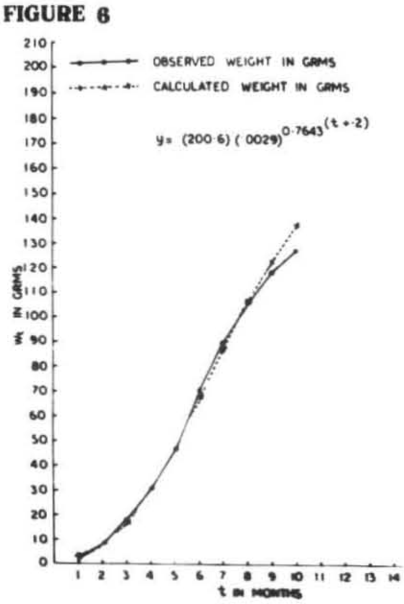


FIGURE 7

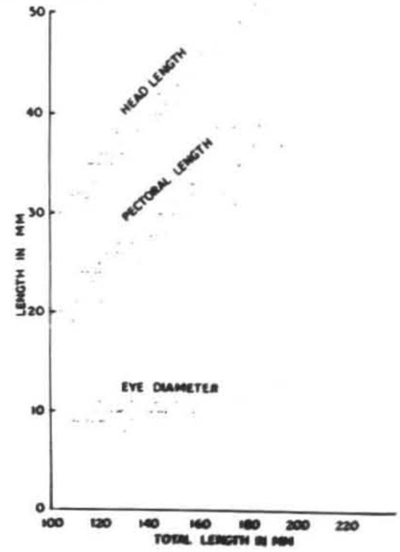
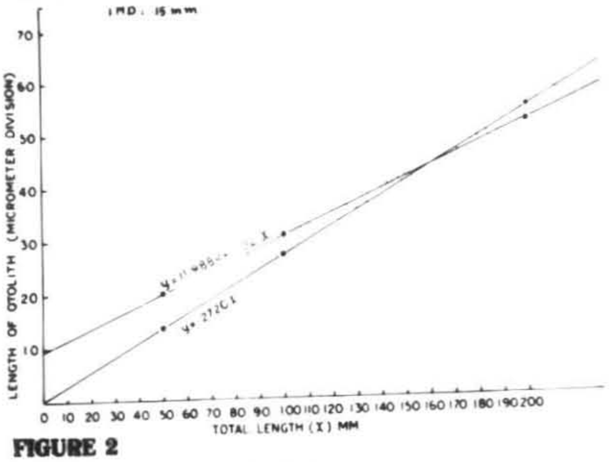


PLATE XVIII

Fig. 1. Relation between total length and otolith length
2. Relation between total length and standard length
3. Relation between total length and head length
4. Relation between total length and snout length
5. Relation between total length and eye diameter
6. Relation between total length and pectoral fin length
7. Relation between total length and second anal spine length

PLATE XVIII

FIGURE 1



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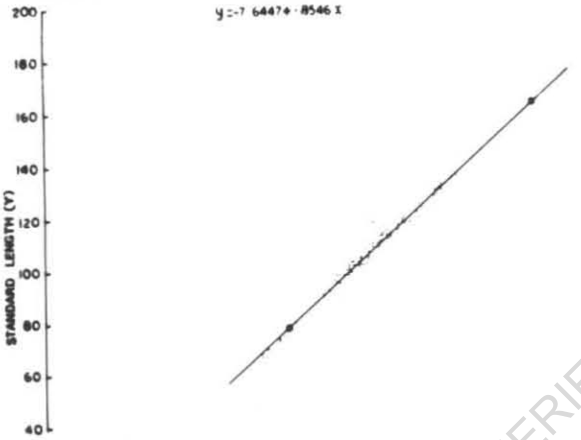

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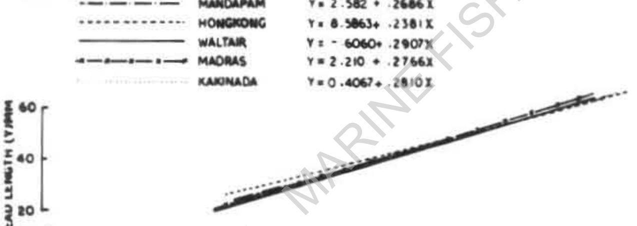

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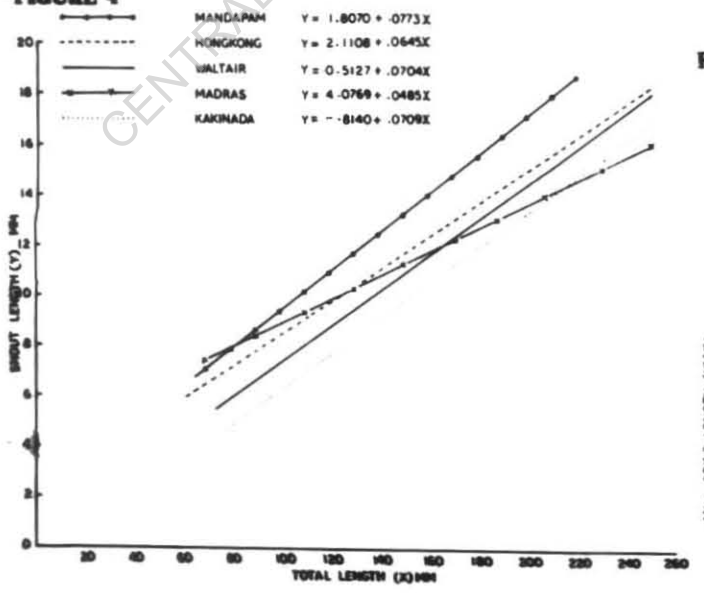

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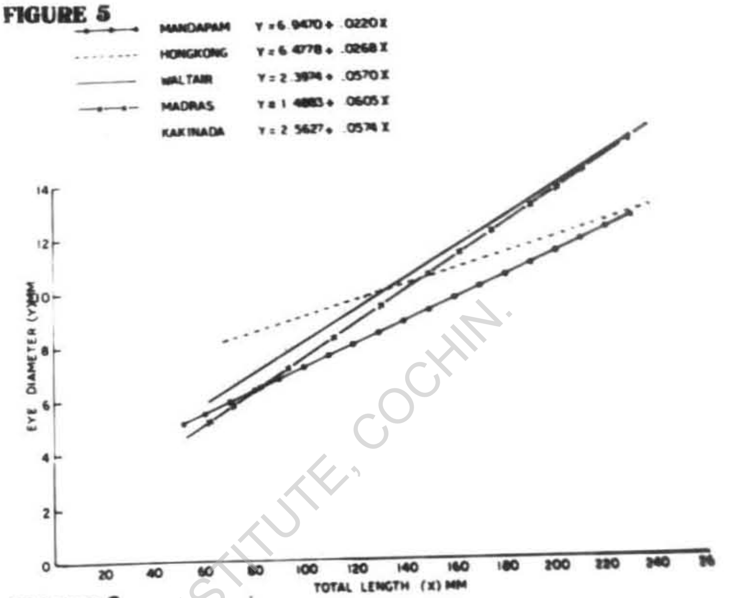

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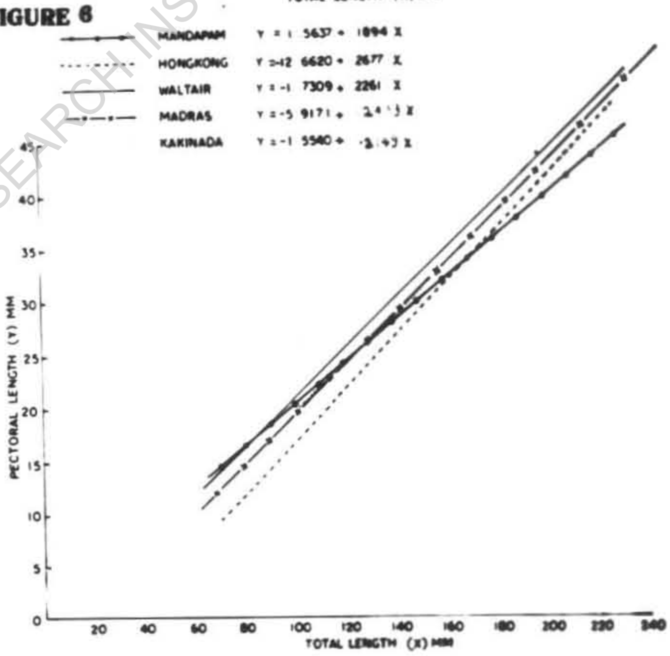

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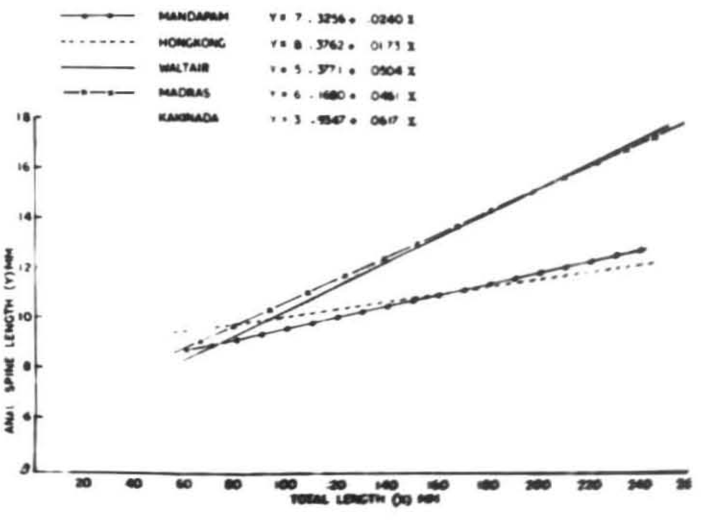


PLATE XIX

Fig. 1. Stages of development of ova

A,B,C - immature ova; D,E - maturing; F - ripe; G,H - residual eggs; I - oil globule

2. *Philometra filamentosa* sp. nov.

A. Anterior end

i. Pharynx; ii. Ovary; iii. Intestine

B. Posterior end

i. Intestine; ii. Ovary; iii. Oviduct

3. *Philometra nairii*

A. Anterior end (enlarged)

i. Lip

B. Anterior end

i. Lip; ii. Ovary; iii. Intestine

C. Posterior end

i. Ovary; ii. Intestine

D. Embryo (taken from the ovary)

i. Intestine

PLATE XIX

FIGURE 1

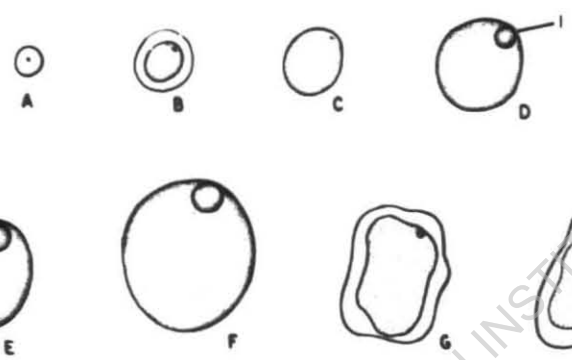
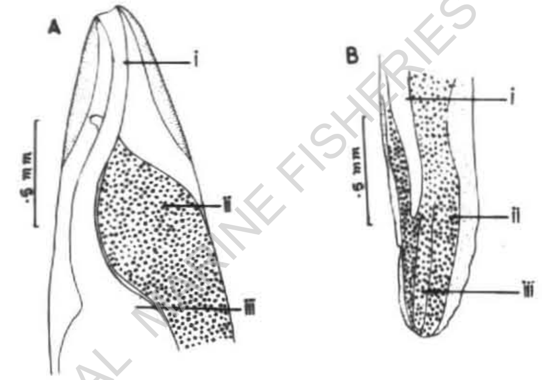


FIGURE 3

FIGURE 2



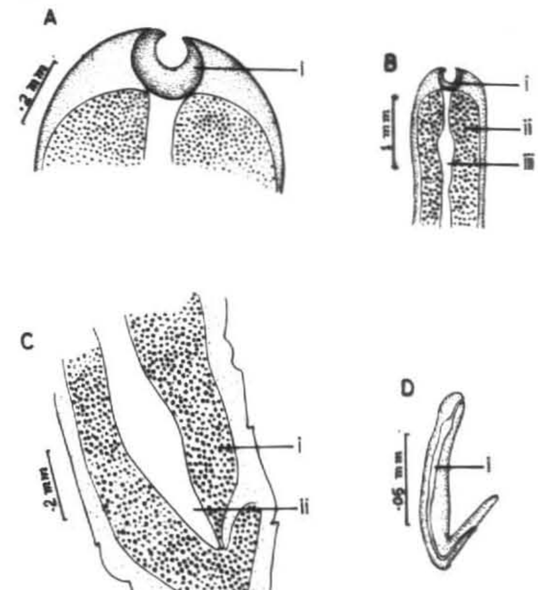


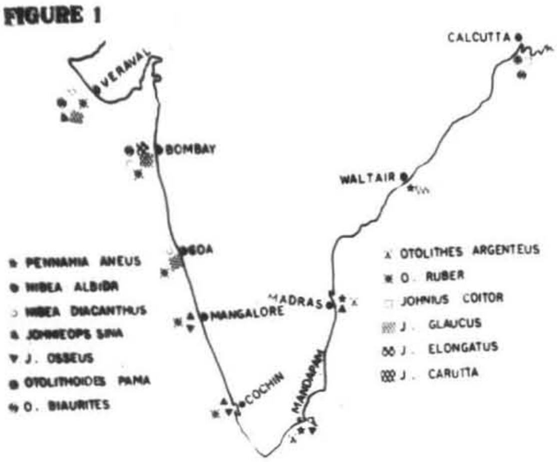
PLATE XX

Fig. 1. Distribution of commercially important species of sciaenids along the Indian coast

2-6. Distribution of various species of sciaenids along the coast of India

PLATE XX

FIGURE 1



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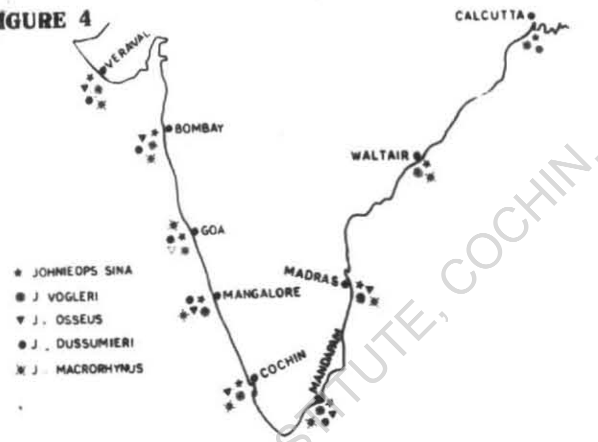

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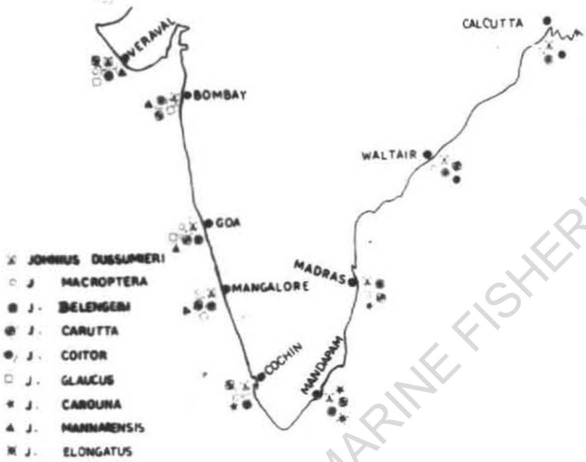


FIGURE 5

FIGURE 3

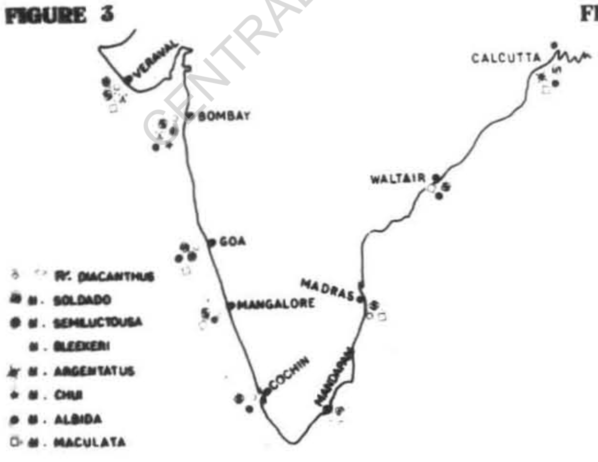


FIGURE 6

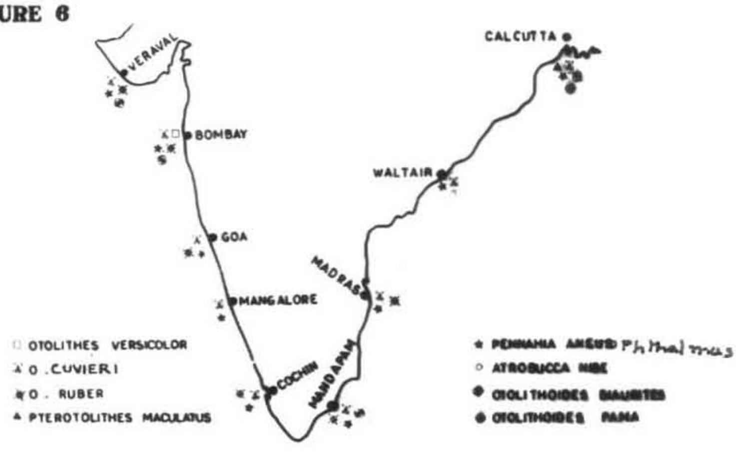


PLATE XXI

Fig. 1 and 2. State wise landings of annual sciaenid fish landings.

PLATE XXI

FIGURE 1

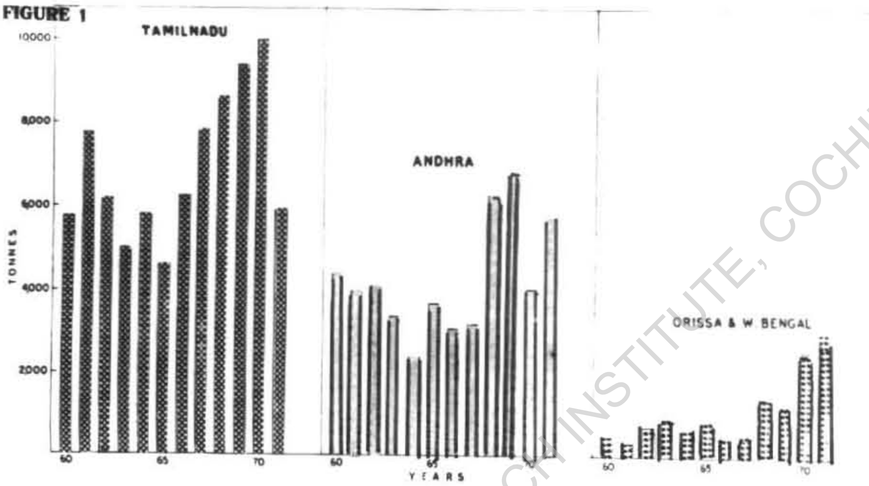


FIGURE 2

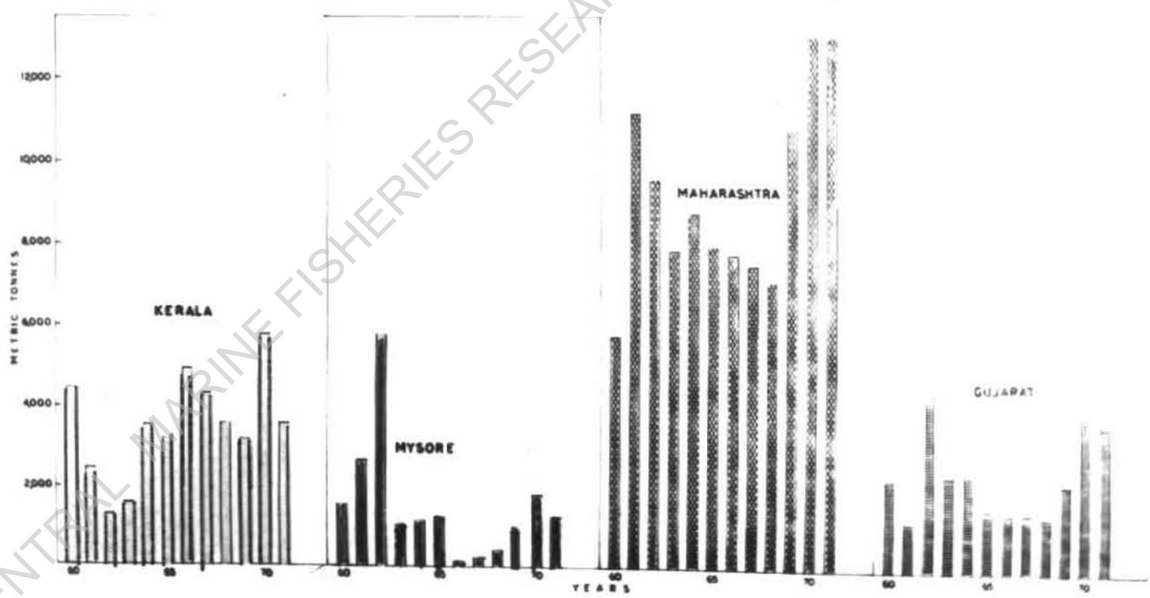


PLATE XXII

Fig. 1. Histogram of the percentage of sciaenid fish landings of different states to the total landings of sciaenids.

2. Histogram of the state wise landings of the sciaenids of east coast to the total annual marine fish landings of India.

3. Histogram of the state wise landings of the sciaenid fishes of west coast to the annual total marine fish landings in India

PLATE XXII

FIGURE 1

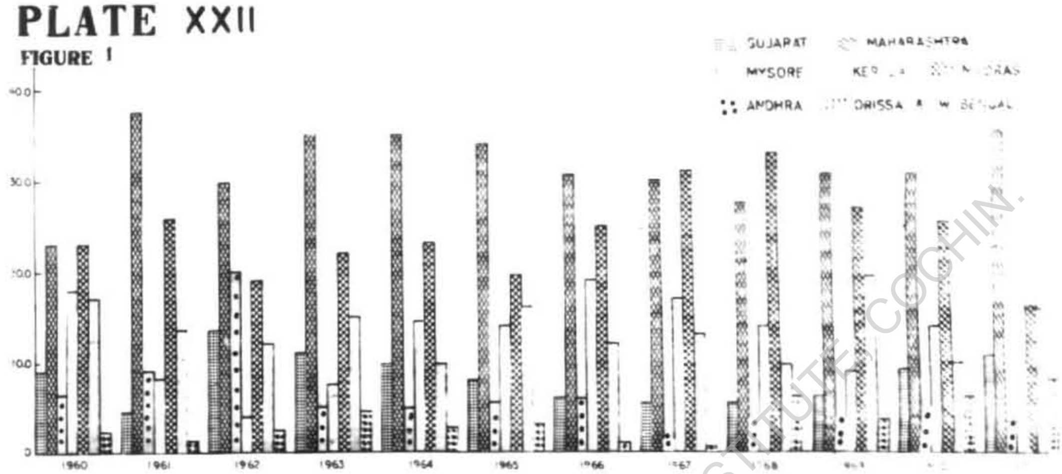


FIGURE 2

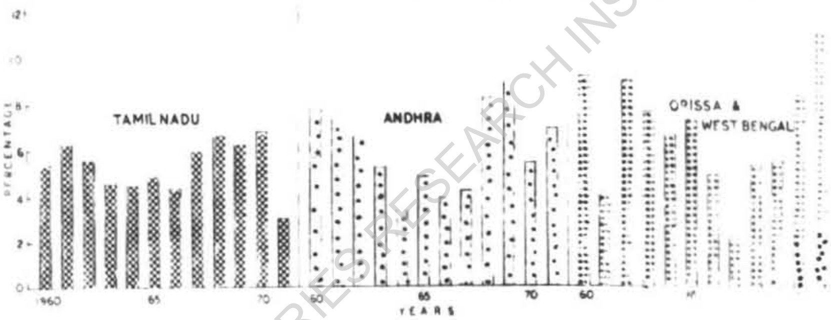


FIGURE 3

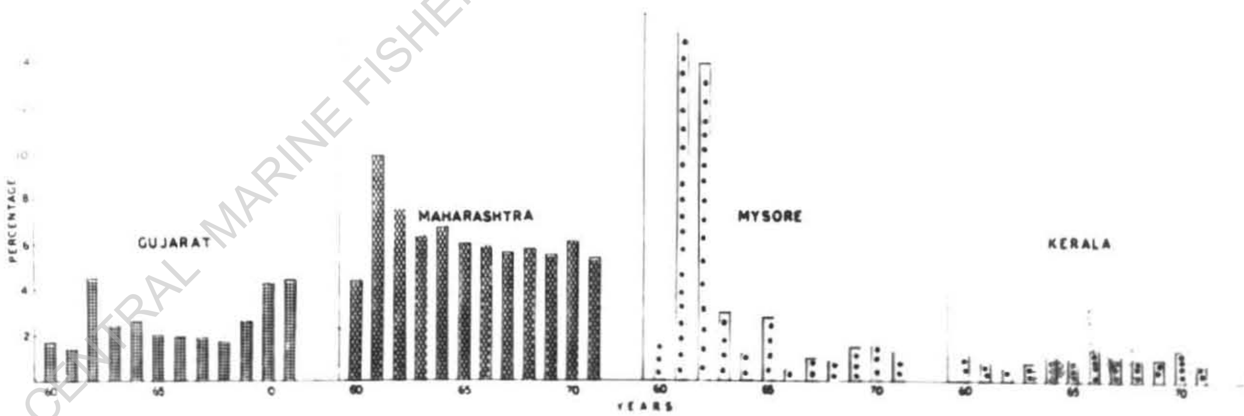


PLATE XXIII

Fig. 1 and 2. Histogram of marine fish landings in India (State wise)

PLATE XXIII

FIGURE 1

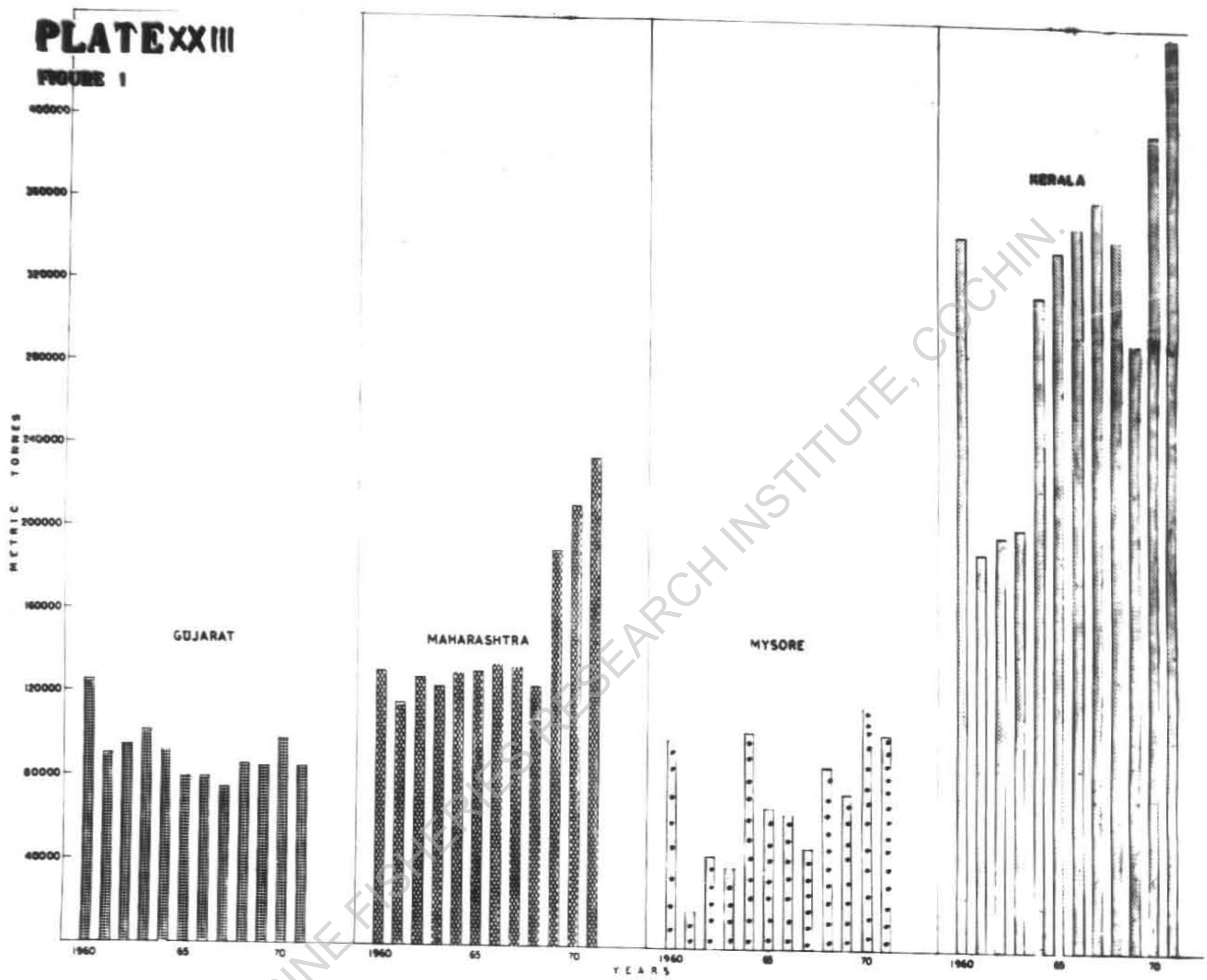
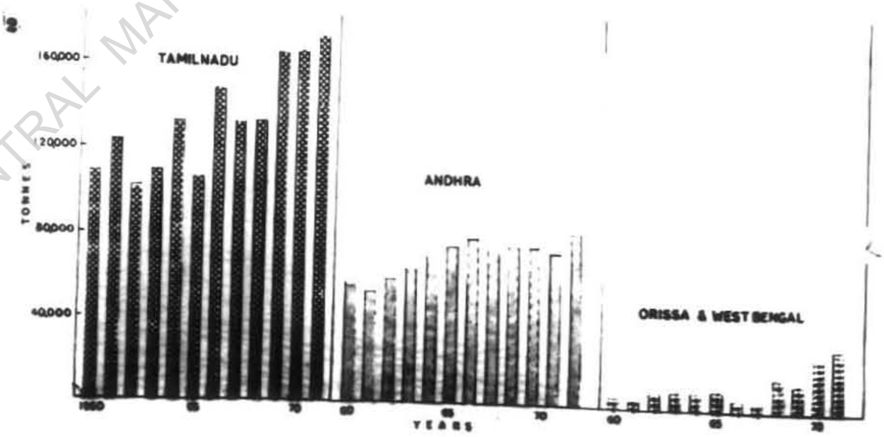


FIGURE 2



APPENDIX - I

LIST OF PUBLICATIONS OF R.S. LAL MOHAN

1. 1963 On the occurrence of Helicore dugon (Muller) from Gujarat coast. J. mar. biol. Ass. India 5(1):152.
2. 1965 A swarm of salp Pegea confoederata (Forskal) from Gujarat coast. Ibid., 7:201-202.
3. 1965 A distributional record of Muraenichthys schultzei from Gujarat coast. Ibid., 7(2):479-481.
4. 1965 Observation on the genus Heniochophilus with a redescription of the type species. Ibdi., 7(2): 270-276.
5. 1967 Tentaculus waltairensis Rao & Dutt, 1965 a junior synonym of Pholicides thomaseni Nielson, 1960 (Pisces: Haliophidae). Copiea, No.2:458-459.
6. 1967 Description of the male Caligus hilsae Shen. Crustaceana, 13:45-48.
7. 1968 A study of growth rings of in otoliths of fish by microradiography. Curr. Sci., 37(11):318-319.
8. 1968 Bibliography of the Indian Ocean 1900-1930. A supplement to the partial Bibliography. Bull. cen. mar. fish. Res. Inst., 411-117.
9. 1969 Bibliography of the Indian Ocean 1931-1961. A supplement to the partial Bibliography. Bull. cent. mar. fish. Res. Inst., 11: 1-178.
10. 1969 Bibliography of the Echinoderms of Indian Ocean. Ibid., 15:1-71.
11. 1969 On three new genera of Sciaenid fishes from India. Curr. Sci., 38(12):295-296.
12. 1969 On the occurrence of the blennoid fishes Blennuis semifasciatus Ruppell (Family: Blennidae) and Tripterygion fasciatum (Weber) (Family:Clinidae) along the Indian Coast. J. mar. biol. Ass. India, 10:114-117.

13. 1969 Some blennies of Gujarat coast with a few new records. J. mar. biol. Ass. India, 10:118-125.

14. 1969 Intertidal fishes of Gulf of Kutch and adjacent shores: Abstr. Proc. Intertid. ecol. Waltair, 1970:2.

15. 1970 Callionymus jonesii, a new callionymid fish (Pisces: Callionymidae) from the East Coast of India. J. mar. biol. Ass. India, 10:(2):357-360.

16. 1970 On the gonadial abnormalities in the Sciaenid fish Pennahia macrophthalmus Bloch, J. mar. biol. Ass. India, 12:165-165.

17. 1970 On the infestation of the nematode parasite Philometra rajani Mukerjee in the gonad of the sciaenid fish Pennahia macrophthalmus Bloch in the Palk Bay. (Bay of Bengal) Ibid., 12:226-227.

18. 1971 Johnius mannarensis a new species of sciaenid from the South east coast of India. J. mar. biol. Ass. India, 11:320-323.

19. 1971 On the occurrence of rare spiny shark Echinorhinus brucus Bonnaterre from the east coast of India. Indian J. Anim. Sci., 41:1011-1014.

20. 1971 Helcogramma shinglensis,a new species of tripterygid fish from Gulf of Mannar with a key to the family Tripterigidae of eastern and central Indian Ocean. Senckenberg. biol. (Frankfurt):52:219-223.

21. 1971 Note on a case of death due to the jelly fish sting in Gulf of Mannar. Curr. Sci., 40:637-638.

22. 1971 First record of the digenetic trematode Astrorchis renicaptis from the leathery turtle Demochelys coriacea Linne from Gulf of Mannar. J. Bombay nat. Hist. Soc., 68:489-490.

23. 1972 A synopsis to the Indian genera of the fishes of the family Sciaenidae. Indian J. Fish.,16:82-98.

24. 1972 Note on the deep sea spined dog fish *Centrophorus armatus* (Gilchrist) (*Selachii*, *Squalidae*) from east coast of India. *Bombay nat. Hist. Soc.*, *69*: 193-199.

25. 1973 *Otolithoides brunneus* (Day) 1873 on a junior synonym of *Otolithoides biauritus* (Cantor). *J. mar. biol. Ass. India* *14*: 145-147.

26. 1973 On a new species of skate *Rhinobatus variegatus*, with notes on the deep sea sharks *Eugaleus omanensis* Norman, Eridacnis radcliffei Smith and *Halaelurus hispidus* Alcock from the Gulf of Mannar *Senckenberg. biol.*, *54*: 71-80.

27. 1973 Note on *Cristiceps halei* Day, 1888 (Pisces: Clinidae) a junior synonym of *Springeratus xanthosoma* Bleeker, 1857, *J. Bombay nat. Hist. Soc.*

28. 1975 The Indian dugong. *Bull. cent. mar. fish. Res. Inst.*, *26*: 1-42.

29. 1975 Report on a case of venenous marine fish sting from Rameswaram. *J. medi. Indian J. Medical Sci.*, 1975.

30. 1976 Two new species of Sciaenid fishes *Johnius elongatus* and *Johnieops macrorhynus* from India. *Matsya*, 1:

31. A new species of philometrid parasite from sciaenid fish *Pennahia macrophthalmus* (in press).

32. Note on the analysis of blood of dugong. *J. mar. biol. Ass. India.* (in press).

33. 1978 Studies on the vocalisation of India sea-cow Dugong dugon in captivity. *Indian J. Fish.*, ~~(in press)~~

34. 1979 Record of Pacific parrot fish *Ypsiscarus oedemar* from Gulf of Mannar (in press). Indian Jour. Fish. 23: 241-242 ~~*J. mar. biol. Ass.*~~ *India.*

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